Unesco–UNEP International Environmental
Education Programme

5

ENVIRONMENTAL EDUCATION: MODULE FOR PRE-SERVICE TRAINING OF TEACHERS AND SUPERVISORS FOR PRIMARY SCHOOLS

UNESCO

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Environmental Educational Series **5**

Environmental Education: Module for Pre-service Training of Teachers and Supervisors for Primary Schools

UNESCO

Division of Science, Technical and Vocational Education

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Preface

A series of experimental modules for the pre-service and in-service training of primary school teachers, secondary school science and social studies teachers in environmental education has been prepared as part of the International Environmental Education Programme carried out by the United Nations Educational, Scientific and Cultural Organization (Unesco) in co-operation with the United Nations Environment Programme (UNEP), and as a follow-up to the recommendations of the Intergovernmental Conference on Environmental Education (Tbilisi, USSR, 1977) concerning the training of teachers in environmental education.

This module aims to foster the acquisition by teachers of knowledge, skills and attitudes useful to teaching about the environment and its problems, to help develop teaching competencies and to stimulate initiative in including the environmental dimension in the primary school curriculum.

The module covers the historial and philosophical background to environmental education; aspects of the environmental education curriculum; teaching methods, activities and experiments; evaluation techniques; and strategies for integrating environmental education into the curriculum.

This book was prepared by Joyce Glasgow, School of Education, University of West Indies, and Pansy Robinson, Ministry of Education, Kingston, Jamaica. It was circulated for comments to twenty professionals and institutions in different parts of the world. A draft was studied by teacher educators at two Subregional Workshops on Teacher Training in Environmental Education (National Council of Educational Research and Training, New Delhi, India, 3–16 March 1983; School of Education, University of West Indies, Mona, Jamaica, 18–29 July 1983). The authors made two revisions of the book on the basis of comments and suggestions received. The final version was edited by Professor Willard J. Jacobson, Teachers College, Columbia University, New York City, U.S.A.

The ideas and opinions expressed in this book are those of the authors and do not necessarily represent the views of Unesco. The designations employed and the presentation of the material throughout the publication do not imply the expression of any opinion whatsoever on the part of Unesco concerning the legal status of any country, territory, city or area or of its authorities, or concerning its frontiers or boundaries.

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Content outline

Introduction

The module is intended for use by teacher trainers and teacher supervisors responsible for the training of teachers for the primary level. The assumption is made that the primary grades are taught by generalist teachers and that pre-service training of teachers is carried out in institutions specially charged with this responsibility.

It is intended for pre-service teachers who may or may not have done courses in the physical and social sciences as integrated or separate disciplines. The content outlined is considered minimum knowledge for the teacher and it is not intended that all of it should be taught at the primary level.

Environmental education is treated as a self-contained course for the teachers and accordingly aims at fulfilling two broad goals:

1. To ensure that pre-service teachers themselves possess the knowledge, cognitive skills and affective attributes they are expected to impart to students at the primary level;
2. To ensure that pre-service teachers acquire these attributes in a manner that satisfies the goals of environmental education and that serves as a model for their own teaching.

Specific objectives

1. To increase environmental awareness, sensitivity and consciousness of pre-service teachers toward the environment, its problems and their prevention and/or solution;
2. To acquaint pre-service teachers with essential knowledge about the environment and its allied problems;
3. To acquaint pre-service teachers with the need for, the importance, the goals, objectives and guiding principles of environmental education;
4. To acquaint pre-service teachers with fundamental environmental concepts which will enable them to manage environmental education in the primary school;
5. To help pre-service teachers realize the totality of the environment as a rationale for the use of the interdisciplinary approach in school;
6. To familiarize pre-service teachers with teaching strategies in environmental education;
7. To familiarize pre-service teachers with certain activities and experiments essential to, and motivating for, the learning and teaching of the environmental dimension of the primary school curriculum;
8. To demonstrate to pre-service teachers the development of unit and lesson plans for environmental education;
9. To familiarize teacher trainers with techniques for assessing the learning of pre-service teachers and their competence/effectiveness in the teaching of environmental education;
10. To orient pre-service teachers towards strategies for the planning, development, implementation of environmental education and for evaluating the progress of primary school students.

Content for environmental education

CHAPTER 1

History and philosophy

Alarm about the pollution of the environment was first raised by ecologists in the technologically and scientifically advanced nations of the world. June 5–16, 1972, marked the success of concerted efforts to bring the problems and the urgent need for remedial and preventive action into world-wide focus through the United Nations. During those days the first Conference of the Human Environment organized by the United Nations was held in Stockholm. There was general agreement that environmental problems were not confined to the nations which first identified them but that they were in fact global in nature, existing across national frontiers. The situation was well defined in the reference to this conference in the report of the Belgrade Workshop (1975) which followed it:

> Our generation has witnessed unprecedented economic growth and techno-logical progress, which, while bringing benefits to many people, have also caused severe social and environmental consequences. Inequality between the poor and the rich among nations and within nations is growing; and there is evidence of increasing deterioration of the physical environment in some forms on a world-wide scale (p. 13).

The danger signals in the physical and social environment were taken to include all the population problems and all the threats to the resources of the earth. More specifically, they were identified as over- and underconsumption, uneven distribution of wealth, and the pollution of the environment.

The Stockholm Conference (1972) agreed on the need for immediate action based on internal understanding and co-operation. It was agreed that the aim of the action would have to be the raising of the standard of the "ecological health of the planet" by improving the

> ...physical and spiritual qualities of our relations to the earth.[1]

The Unesco-UNEP International Environmental Education Programme (IEEP) was set up in 1975 by Unesco in cooperation with UNEP in response to Recommendation 96 of the Conference. This recommendation stated, in part, that the Secretary General, all United Nations organizations, especially Unesco and all international agencies, should, through consultation and agreement, take steps to establish an international programme in environmental education. The Conference also arrived at some broad guidelines for the programme. It was to be

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[1] Fensham, Pet J. Stockholm to Tbilisi – The Evolution of Environmental Education. *Prospects: Quarterly Review of Education*, Vol. VIII, No. 4, 1978, p. 447.

> ...interdisciplinary in approach, in-school and out-of-school, encompassing all levels of education and directed towards the general public, in particular the ordinary citizen living in rural and urban areas, youth and adult alike, with a view to educating him as to the simple steps he might take, within his means, to manage and control his environment (p. 19).

Certain aspects of the work of IEEP can be summarized as:

1. collection, systematization and circulation of information about individuals and institutions active in environmental education;

2. the study, trial and development of innovations in environmental education through selected pilot projects in every region of the world to develop new methodology, curricula, materials and programmes for formal and non-formal education;

3. discussion and exchange of information about policies and strategies for environmental education to aid the processes of reflection, conceptualization and clarification of all aspects of environmental education and training in order to promote the co-ordination of environmental education at the international level.

At the International Workshop on Environmental Education in Belgrade, October 13–22, 1975, educational experts from sixty-five countries were present to consider information collected by IEEP, to review and discuss trends and emerging issues in environmental education, to formulate preliminary guidelines and make recommendations for the further development of environmental education.

The results of the deliberations of this Workshop were contained in a document — the Belgrade Charter — which spelled out a framework and a set of guiding principles for environmental education. The recommendations were concerned with research, with environmental education as life-long education, with the development of programmes, the role of the mass media, the training of personnel, instruction materials, funding, and evaluation. The Belgrade Charter went further and set the educational programme in the context of new, universal, socio-economic goals. To quote:

> The recent United Nations Declaration for a New International Economic Order calls for a new concept of development — one which takes into account the satisfaction of the needs and wants of every citizen of the earth, of the pluralism of societies and of the balance and harmony between humanity and the environment. What is being called for is the eradication of the basic causes of poverty, hunger, illiteracy, pollution, exploitation and domination.
>
> ...The resources of the world should be developed in ways which will benefit all of humanity and provide the potential for raising the quality of life for everyone (p. 13).
>
> ...This new kind of development demands the assurance of perpetual peace through co-existence and co-operation among nations with different social systems. Substantial resources for reallocation to meet human needs can be gained through restricting military budgets and reducing competition in the manufacture of arms. Disarmament should be the ultimate goal.
>
> ...These policies aimed at maximizing economic output without regard to its consequence on society and on the resources available for improving the quality of life must be questioned. Before this changing of priorities can be achieved, millions of individuals will themselves need to adjust their own priorities and assume a personal

> and individualized global ethic — and reflect in all their behaviour a commitment to the improvement of the quality of the environment and of life for the world's people.
>
> ...The reform of educational processes and systems is central to the building of this new development ethic and world economic order... This will require new and productive relationships between student and teachers, between schools and communities, and between the education system and society at large (p. 14).[1]

The challenge to the individual, to education and to society as a whole is clear.

The Belgrade Workshop was followed by a series of regional meetings held in Brazzaville for Africa, Bangkok for Asia, Kuwait for the Arab States, Bogota for Latin America and the Caribbean, Helsinki for Europe. Using the Charter as a starting point and frame of reference, the task of each regional meeting was to examine environmental problems peculiar to the region and to recommend action which would be suited to the physical, socio-economic and cultural dimensions of the countries of each region. The recommendations of these meetings were documented and served as part of the resource material for the Intergovernmental Conference on Environmental Education in Tbilisi, Georgia, USSR organized by Unesco in co-operation with UNEP from October 14–26, 1977.

This Conference, attended by sixty-six Member States of the United Nations, was highly significant in the development of environmental education. It stands, at present, as the final act in the thrashing out of definitive statements about environmental education. As stated in the Preface to the Unesco publication, *Environmental Education in the Light of the Tbilisi Conference*, it became

> ...the starting point for an international environmental education consistent with the wishes of all the Member States. In particular, it helped to specify the actual nature of environmental education by laying down its aims and characteristics as well as the strategies to be adopted at the national and international levels (p. 5).

It is useful, for our purposes, to quote here the first part of Recommendation 1[2], which can be said to constitute the criteria for the development of environmental education:

> 1. Whereas it is a fact that biological and physical features constitute the natural basis of the human environment, its ethical, social, cultural and economic dimensions also play their part in determining the lines of approach and the instruments whereby people may understand and make better use of natural resources in satisfying their needs.
>
> 2. Environmental education is the result of the reorientation and dovetailing of different disciplines and educational experiences which facilitate an integrated perception of the problems of the environment, enabling more rational action, capable of meeting social needs, to be taken.
>
> 3. A basic aim of environmental education is to succeed in making individuals and communities understand the complex nature of the

[1] The International Workshop on Environmental Education (Belgrade, Yugoslavia, 13–22 October 1975). *Final Report* (Doc. Unesco ED-76/WS/95).

[2] Intergovernmental Conference on Environmental Education (Tbilisi, U.S.S.R., 14–26 October 1977). *Final Report*, p. 25 (Doc. Unesco/ED/MD/49).

natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems, and the management of the quality of the environment.

4. A further basic aim of environmental education is clearly to show the economic, political and ecological interdependence of the modern world, in which decisions and actions by the different countries can have international repercussions. Environment should, in this regard, help to develop a sense of responsibility and solidarity among countries and regions as the foundation for a new international order which will guarantee the conservation and improvement of the environment.

5. Special attention should be paid to understanding the complex relations between socio-economic development and the improvement of the environment.

6. For this purpose, environmental education should provide the necessary knowledge for interpretation of the complex phenomena that shape the environment, encourage those ethical, economic and aesthetic values which, constituting the basis of self-discipline, will further the development of conduct compatible with the preservation and improvement of the environment; it should also provide a wide range of practical skills required in the devising and application of effective solutions to environmental problems.

7. To carry out these tasks, environmental education should bring about a closer link between educational processes and real life, building its activities around the environmental problems that are faced by particular communities and focusing analysis on these by means of an interdisciplinary, comprehensive approach which will permit a proper understanding of environmental problems.

Following the Tbilisi Conference, Member States responded positively by undertaking the development of environmental education and also by introducing legislation to protect the social and physical environments. As an example of this action, two conferences (sponsored jointly by UNEP and ECLA — Economic Commission of Latin America) have been held in the Caribbean and Latin America region. These conferences resulted in the adoption of the Caribbean Action Plan containing sixty-six projects aimed at strengthening the institutional framework for management of resources and development of the region. One of these projects related to environmental education. Representatives to this conference came from thirty countries, representing the governments of Caribbean states, Latin American states, the United States of America, France, the United Kingdom and the Netherlands.

Educators all over the world have been pressing ahead with their task. In the formal system, according to a Unesco report, environmental education has received inputs from primary schools to universities. The teaching approach has been interdisciplinary or by infusion. In certain universities, environment-related topics have been introduced into the traditional disciplines. Central to the educational activities has been the training and retraining of teachers. Educational activities have also been carried out in a nonformal manner by clubs, political movements, trade unions. Target groups have been farmers, engineers, architects, landscape gardeners, public health specialists, planners and directors of public and private services. Educational activities have included excursions, lectures, participation in health education and environmental protection campaigns, nature-preservation camps and nature clubs, framing and implementation of com-

munity planning. Learning resources have been the environment itself, audio-visual and printed materials, zoological and botanical gardens, museums, and nature trails.

Activities aimed at improving the ecological health of the planet have become objectives in the programmes of several United Nations organizations.

Towards a philoshophy for environmental education

National education systems are generally considered to be rooted in some philosophy — some system of beliefs, ideology or convictions about living — from which a type of person, certain ethical or moral principles and certain values are extracted to serve as the desired goals of education. The educational process then concerns itself with the encouragement of those values, attitudes and actions which reflect the national philosophy. The last five centuries, however, have brought the world closer together and so, educational philosophies, as well as other cultural features, have crossed national frontiers.

Thus the call for environmental education becomes a call for global action in response to the problem of the abused environments — physical and social — of the whole world. The call is to each national education system to foster and encourage the development of world citizens, internationalists, who share a concern for the environment in which they now live and in which their descendants will also have to live. The following outline attempts to identify certain beliefs and attitudes which, it is thought, should characterize the world citizen/internationalist and which would therefore serve as the underlying philosophy/affective goals of environmental education.

There are two characteristics of the world citizen that can be mentioned: firstly the citizen should be self-disciplined and secondly, the personal ethic must include a global/international dimension. The need for the quality of self-discipline is supported by Mumford (1944) who saw the lack of it as one reason why man became threatened by the very things he valued most — power, mastery over natural forces, the scientific addition to knowledge. He clarified the concept of self-discipline in his definition of "balanced personalities" as

> ...personalities that will be capable of drawing upon our immense stores of energy, knowledge, and wealth without being demoralized by them (p. 415).

The global dimensions demands that each world citizen see himself/herself as a guardian of the national and international good, developing and using the skills of negotiation and compromise to resolve situations of conflict.

These demands strengthen the movement towards new ways of thinking about our world and consciously changing the nature of national and international goals. It means a re-assessment and possible abandon of previously accepted priorities in scientific, social, economic, and political spheres. It means broadening the narrow concerns of governments which have prevailed during the last five centuries so that national goals contribute to the corporate good of the world of nations, of the planet as a whole.

In making personal life plans, the individuals would ensure that their choices (in art, science, truth, beauty, religion) will add enrichment to makind as a whole. As guardian of national and international good, the citizen would view economic activity as a means of raising the quality of life for all and would ensure that such activities are planned and implemented in such a way as to put an end to those social ills identified as poverty, hunger, illiteracy, pollution, exploitation and domination. The world citizen would question those economic policies which aim solely at maximizing output without regard to its consequence on society. The world citizen would

examine each political and economic measure to determine how far it will support co-operation rather than conflict between nations. The world citizen would scrutinize every industrial innovation to ensure that it produced not only material good but also good people. Discoveries in science and technology would be examined in the light of their potential for good as well as for any adverse effect on the total environment and the quality of life, and the improved quality of life would be made to supercede all other considerations. All public plans would be evaluated in terms of the fulfilment and renewal of the human person. The citizen must, however, go beyond questioning and be willing and capable of planning and implementing action to improve the health of the planet. This "world citizen" represents the ideal personality that teachers of environmental education must seek to develop.

The tenets of this new philosophy translated into an all embracing goal for the guidance of teachers of environmental education were succintly expressed at the Belgrade Workshop (1975) in this way:

— be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

— examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

— focus on current and potential environmental situations, while taking into account the historical perspective;

— promote the value and necessity of local, national and international co-operation in the prevention and solution of environmental problems;

— explicitly consider environmental aspects in plans for development and growth;

— enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

— relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

— help learners discover the symptoms and real causes of environmental problems;

— emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;

— utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.[1]

It follows from these objectives and guiding principles that there is a certain knowledge component which is essential as a base for building the skills and fostering the attitudes which are the main focus of environmental education. Elements of this knowledge component are given in the section which follows.

> To develop a world population that is aware of, and concerned about the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively towards solutions of current problems and the prevention of new ones (p. 15).

The Objectives and Guiding Principles for environmental education consonant with this overall goal were formulated at the Tbilisi Conference (1977), and are internationally accepted. These are:

[1] Intergovernmental Conference on Environmental Education, p. 26–27.

Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.

Knowledge: to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems.

Attitudes: to help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.

Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.

Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems.

Guiding principles

Environmental education should:

— consider the environment in its totality — natural and built, technological and social (economic, political, technological, cultural-historical, moral, aesthetic);

— be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;

— be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

— examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

— focus on current and potential environmental situations, while taking into account the historical perspective;

— promote the value and necessity of local, national and international co-operation in the prevention and solution of environmental problems;

— explicitly consider environmental aspects in plans for development and growth;

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[1] Intergovernmental Conference on Environmental Education, p. 26–27.

CHAPTER 2

The environment

The environment encompasses everything, living and non-living objects, the interactions between these and the products of these interactions. Both sets of 'reactants' are open to change as a result of their interaction. Thus the environment must be thought of both as being plural in view of the many situations which exist for reciprocal influence, and as being infinite because of the variety of such situations.

One may conveniently regard the environment as encompassing two basic facets — the biophysical and the socio-cultural. The first covers the biological and physical aspects, and the second, man's economic, political and intellectual activities. The biophysical carries its own set of reactions, and provides the medium for the socio-cultural; and there are the interactions between these two basic facets which are really, in life, not separable.

Thus the concept of the environment in its totality is a complex one, far-ranging in its implications, and challenging to man's understanding.

This chapter will treat at a basic level the facets suggested above under four headings:

(a) Biophysical Components
(b) Ecosystem Interrelationships
(c) Socio-cultural and Economic components
(d) Interactions between the Biophysical and the socio-cultural components

The biophysical components

The earth is a system within systems — it is part of a much larger scheme of things, about which our knowledge is limited. Our sun is an incandescent ball of gases, a star around which revolve nine planets of which the earth is but one. Figure 1 illustrates this.

Billions of other stars exist; one estimate suggests 100 million million million! Those with dust and gas form large groups or galaxies of which there are an estimated 100 billion in the Universe, each formed into a system by gravitation.

The planets maintain an elliptical path or orbit around the sun, each held in position by the speed of its own revolution and the gravitational pull of the sun. Every body in the universe 'pulls' on every other body — it is this pulling force which is known as gravity.

Table 1 summarizes some of the known characteristics of the planets. It can readily be seen that only Earth has an atmosphere with oxygen and an average temperature which can support life as man knows it. The position of the earth relative to the sun is a critical factor in its uniqueness. The sun serves as the earth's ultimate source of energy, and as the mainstay of the basic life-sustaining energy conversion reaction, photosynthesis, it is the most important single factor influencing living systems. Its effect on these systems is both direct, as its rays impinge on them; and indirect, through its influence on weather and climate, rocks and soils.

It is the weather and climate, rocks and soils which comprise the abiotic or physical components of the environment. These are discussed under three subheads:

Climatic factors

Light affects photosynthesis, and reproductive cycles in plants and animals.

Temperature influences all biochemical processes. These can only be maintained efficiently over a narrow temperature range. For this reason, living organisms must avoid extremes of temperature or somehow accomodate themselves to them. For example, poikilothermic animals (those without a built-in mechanism for maintaining a steady body temperature) are largely limited. Those animals (the birds and the mammals) which have developed a mechanism for maintaining a steady body temperature can live in areas with a wider range of temperature. Temperature also affects transpiration or water loss from the aerial parts of plants, as well as water loss from animal surfaces. In general, increasing temperature means increasing evaporation.

Precipitation — rainfall, dew, snow, hail, frost — are all various forms in which water reaches the surface of the earth. Water is essential to the existence of almost all living things. Both the total amount of precipitation, as well as how it is distributed throughout the year, are important, in determining what types of plants and animals can live in any area, and in what abundance they can exist.

Wind has direct mechanical effects on vegetation, shelter, soil, sea. For example, trees growing near to the sea often lose the foliage on the side exposed to the wind. Trees which provide shelter for some organisms may be blown down. Soil can be blown away. There are also indirect effects through the translocation of matter carried from one place to another — particulate matter like sand, dust or pollen, or fluid matter like water vapour and waste gases from industrial installations.

Physiographic factors

Altitude — height above sea level — has implications for temperature and atmospheric pressure — with increasing altitude, both decrease. Populations, plant and animal, decrease in size, as do human populations.

Steepness of slope affects the angle of insolation (slant of the sun's rays) on a slope, as well as the stability of the land surface. Closely related is *aspect.* For example, in the Northern Hemisphere southward facing slopes receive a higher concentration of the sun's rays than northward facing slopes and can, therefore, support different life forms.

Weathering and erosive agents include sea, wind, rain, ice, etc. As erosive agents they remove soil; as weathering agents they help to build soil from parent rock by helping to break it down.

Nature of underlying rock of an area affects the stability of the soil surface, the topography of the land, the presence/absence and nature of any deposits of mineral ores.

Edaphic or soil factors

Nature of the parent rock determines both the size of soil particles and thus their capacity to hold water and air, as well as the chemical composition of a soil. This means that the elements/minerals that the soil contains and which determine its suitability for sustaining vegetation, are mainly dependent on the type of rock from which it originated.

Humus influences the structure and water holding capacity of the soil. Humus, both increases the capacity of sandy soils to hold water, and promotes drainage in heavy soils. The amount of humus also affects the acidity/alkalinity of the soil (pH). Different plants can tolerate different pH ranges. Very importantly too, humus provides the substrate which supports

TABLE 1

CHARACTERISTICS OF THE PLANETS

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
*Temperature** Mean average temperature on the surface of the planet	Day 640 °F Night −180 °F	720 °F	60 °F	−45 °F	−240 °F	−290 °F	−360 °F	−380 °F	−450 °F ?
*Atmosphere** Major chemical components	not permanent	carbon dioxide; nitrogen, water vapour	nitrogen, oxygen, water vapour, carbon dioxide, argon	carbon dioxide, nitrogen, water vapour	hydrogen, helium, methane, ammonia	hydrogen, helium, methane, ammonia	hydrogen, methane	hydrogen, methane	?
Average *distance* from the sun** (in millions of km)	58	108	150	228	780	1427	2870	4499	5960
*Sidereal period** Period of time in earth days to make one revolution around the sun	88 days	224.7 days	365.26 days	687 days	11.86 years	29.46 years	84.01 years	164.8 years	247.7 years
*Period of rotation** Period of time for planet to make one rotation on its axis	58.6 days	244 days (retro-grade)[1]	23 hrs. 56 mins.	24 hrs. 37 mins.	9 hrs., 50 mins.	10 hrs., 14 mins.	10 hrs., 49 mins.	14 hrs.	6.4 days
Approximate diameter in km**	4 800	12 300	12 756	6 790	142 800	119 500	47 100	44 800	5 900

[1] Retrograde = in the direction opposite that of the sun and the other planets.

* Source: Whittingham, Richard. *Astronomy*, Hubbard, Illinois, 1975.

** Source: 'The Earth and Beyond', UWI UNESCO UNICEF FUNDP Unit in RLA 142 series for Caribbean Teacher Training Colleges, 1975.

micro-organisms: the action of these organisms releases the mineral nutrients stored in dead organisms so that they can be used again. Earthworms, which are important aerators of the soil, also feed on humus.

All the physical factors are closely associated, and the set of conditions they produce in any particular area, determines the kind of organisms which can exist there. In turn, the biological and physical factors interact in ways which influence both, and contribute to the kind of habitat which develops in that area.

Biological components

The biological components comprise *all* living organisms — plants, animals, bacteria, viruses. They include a variety of species showing a range of complexity from one celled units which carry out all the functions of life, to highly complex organisms like the flowering plants and the mammals. The organic remains of dead organisms may also be considered biological components.

Living organisms with similar habitat requirements tend to occur together in localities which meet their need, and for which they have become adapted. In each habitat at an individual species occupies a particular 'living space', feeding, reproducing etc. in a way which differentiates it from organisms in other niches. For example, in shallow water on a sandy tropical shore, brittle sea stars are found under stones, sea anemones buried in the sand, but fish in open water. Some organisms may even have niches which go across habitat types. Frogs and toads are aquatic and feed on vegetation in their larval stages. The mature animals feed on insects, must live in moist places, but return to water to lay their eggs. Migratory birds and fishes span several types of habitat as they cross continents in their journey from feeding grounds to breeding ground and vice versa.

Two characteristics of living organisms which are evident in the way they relate to their environment are here selected for especial comment. The first is the variety of types of relationships which have evolved. These include relationships between species e.g. competition between 'equals', predator/prey, parasite/host, commensalism (where organisms of two species 'live together' without harm) and symbiosis (where mutual benefit accrues to both organisms through their association). Relationships within species also show different levels of social organization. There is the rather loose associations of some birds which separate to feed during the day, but roost together at night. There are also groups which keep together as a unit, feeding and reproducing, e.g. a herd of cattle. In a third category, the social insects like the honey bees, show a very high level of structure in their living patterns.

Secondly, regardless of level of complexity, organisms in a particulare nvironment in reacting to similar conditions show similar adaptations. For example, camels and cacti in adapting to life in conditions of water stress have developed means of storing water. Barnacles and whales in an aquatic environment both use filter feeding mechanisms which enable them to make use of the small, but numerous planktonic forms. The protozoan Amoeba and bony fresh water fish with body fluids hypertonic to the water around them, both face the danger of 'bursting' from the intake of too much water. In both there has developed a means of disposing of unwanted water periodically.

Man, despite his ability to manipulate many factors in the environment, including himself, exhibits both of these characteristics in his social organization. The variety of relationship types exists — from equal competition to symbiosis.

In short, organisms do not exist in isolation. In the section which follows, some of the interrelationships among living organisms, and between them and the physical environment are discussed.

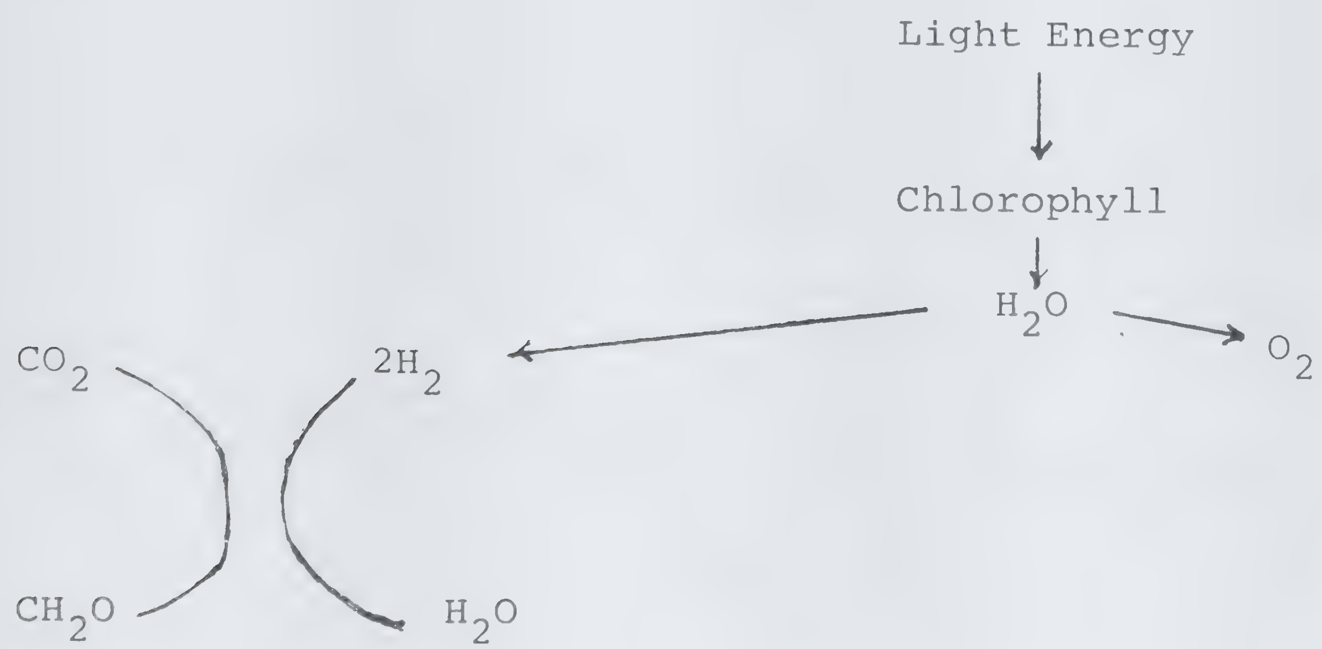
Ecosystem dynamics

The most basic or fundamental of interactions in natural systems is that involving food and energy. Except for nuclear energy and tidal geothermal energy, almost all the energy used on the earth comes from the sun, and is made available to living organisms through the agency of green plants. In the process of photosynthesis they convert radiant energy into the chemical energy of carbohydrate — a form in which both plants and animals can utilize the energy.

While the processes involved can be complicated, the overall process may be represented by the following equation:

$$6\,CO_2 + 12\,H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6\,H_2O + 6\,O_2\uparrow$$

Light energy is captured by chlorophyll, and used to break down water. In a series of complicated reactions, the oxygen component is released into the atmosphere, and the hydrogen reduces carbon dioxide to carbohydrate material of the basic formula (CH_2O).

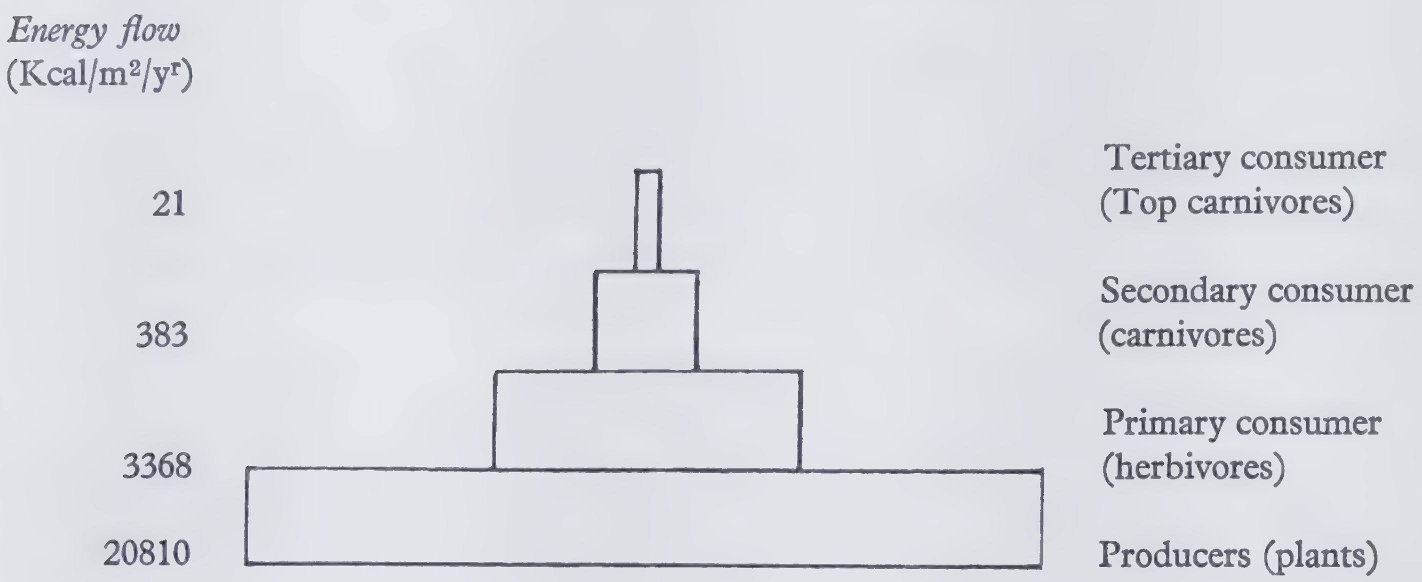


Certain bacteria also have special methods of respiration which allow them to oxidize various inorganic materials like hydrogen sulphide, ammonia, iron, and to use the energy so liberated to synthesise organic compounds from carbon dioxide and water. These bacteria thus introduce into living systems a supplementary but quantitatively insignificant source of energy.

The organisms that can produce food may be termed the *producers* of the system. Feeding directly on the plant producers are the *primary consumers*, the herbivores, which in turn are used by *secondary consumers*, the carnivores, of which there may be several levels. Some energy is lost in the respiration of organisms; therefore, at each level, the amount of energy which is passed on decreases, as is illustrated in Figure 1 from data for Silver Springs, Florida.
Thus the passage of energy in the system is a one-way flow, not a cycle. Decay organisms cause the recycling of inorganic nutrients to renew plant and animal populations.

The basic relationships in any system which involves the living and nonliving components of a particular area interacting so that a flow of energy leads to clearly defined trophic structure, biotic diversity and exchange of materials, are illustrated in a generalized way in Figure 2.

Figure 1: Energy Content Pyramid for Silver Springs, Florida*



*Source: E. P. Odum 1971 (p. 80)

Within this system of relationships, or *ecosystem*, the functioning units are linked together in a complex way, forming food chains, or more often, food webs.

A simple terrestrial food chain might be —

grass ⟶ insect ⟶ toad

A simple terrestrial food web might be represented by

grass ⟶ cow ⟶ man
↓ ↓
humus ticks
↓ ↓
earthworm ⟶ egrets

A simple fresh water aquatic food chain might be represented as

phytoplankton ⟶ insect larvae ⟶ small fish ⟶ large fish

Food chains are of two types:
— *grazing chains* begin from a green plant base, lead to grazing herbivores (plant eaters), and then to carnivores (animal eaters),
— *detritus chains* begin with dead organic matter, which releases material for the use of micro-organisms; these are consumed by detritus feeders, which are, in turn, devoured by their predators.

As already mentioned, food chains are not usually isolated, but are interconnected to form complicated food webs. Organisms which derive their food from plants by the same number of steps are said to belong to the same trophic level.

Figure 2: Net Flow of Energy and Nutrients through a Natural System*

Source: Woodwell, George M. "The Energy Cycle of Biosphere" in Scientific American, Vol. 223, N⁰ 3, 1970 (p. 67)

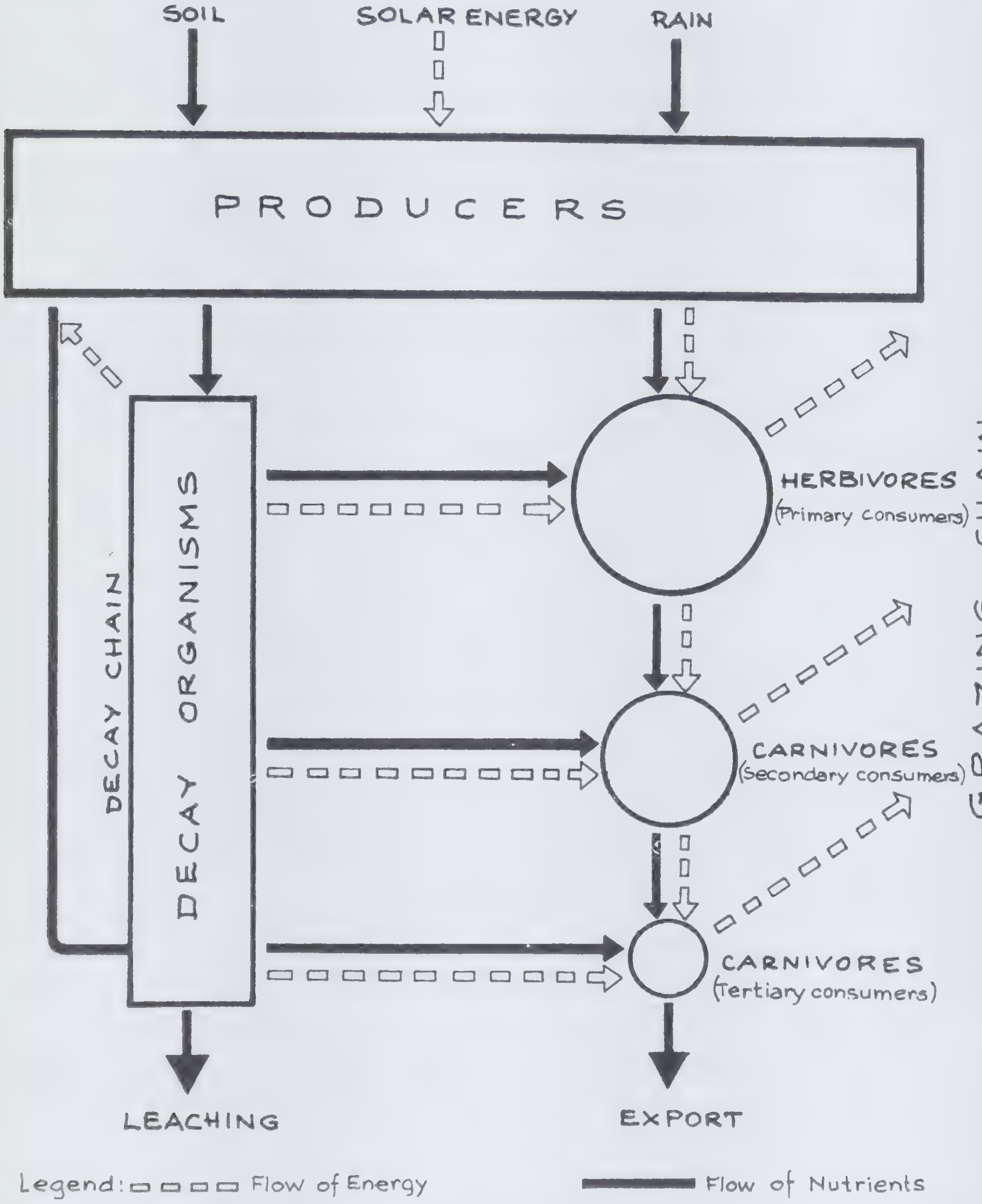


Figure 3 is a diagrammatic representation of the food relationships within a Thalassia bed in the shallow coastal waters along the Palisadoes, Jamaica. Both the complexity of a food web, with grazing and detritus chains, and the concept of trophic levels are illustrated.

Where the ecosystem is a balanced one, competition is such as to keep each section of the populations at a level at which none is threatened, and each can retain its individuality. Thus there is an optimum number of organisms at each trophic level which can be accommodated. This number decreases with movement away from the primary producers so that there is a *pyramid of numbers*. This is illustrated diagrammatically (Figure 5) for the simple terrestrial food chain postulated earlier.

This pyramid of numbers parallels the pyramid of energy discussed earlier.

The total mass of living matter or biomass which can be supported at each trophic level at a particular time also gets less in a natural system as we move up in a food chain, resulting in a *pyramid of biomas* or standing crop. The size of the organisms, however, tends to get larger as we move up the food chain.

Figure 3: Thalassia Bed eco-food System, Coastal Waters, Palisadoes, Jamaica.*

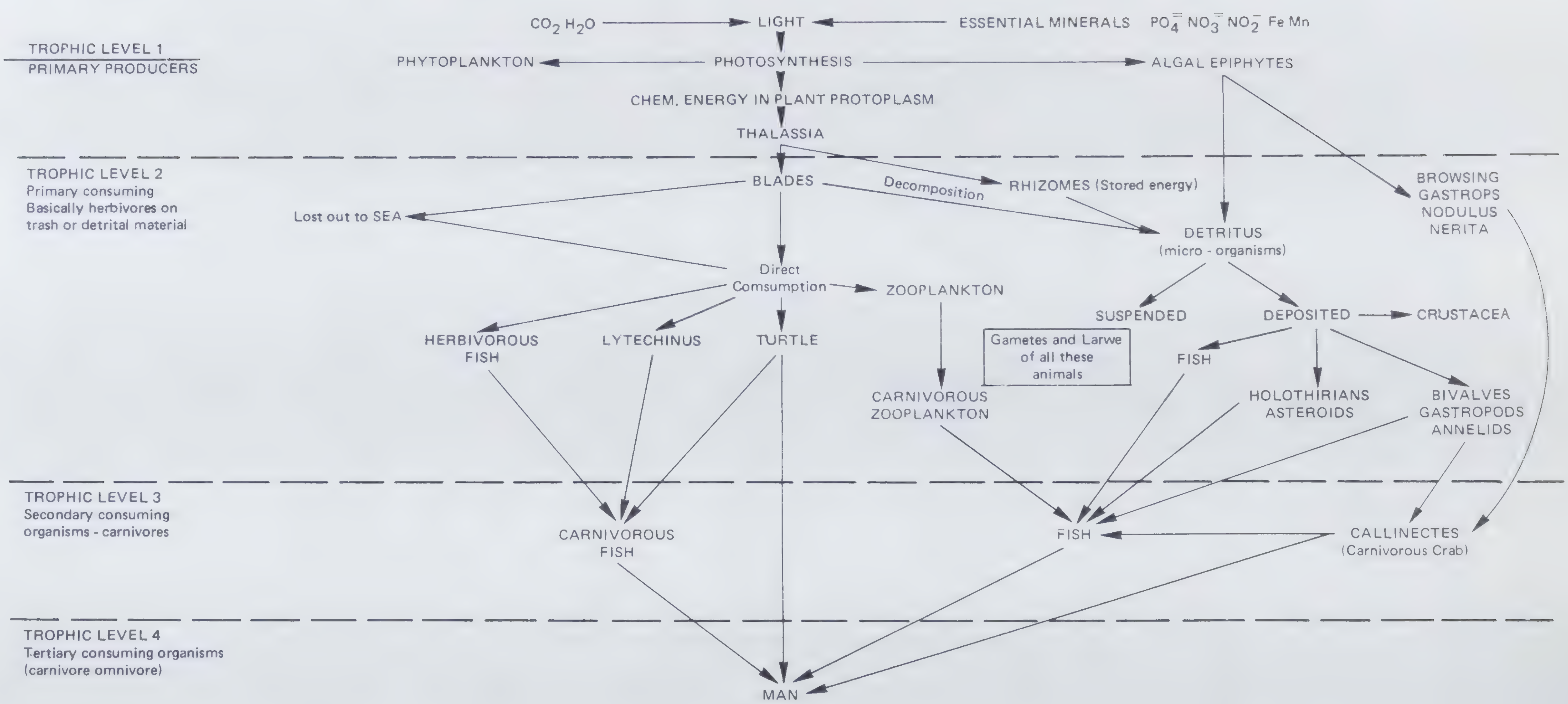
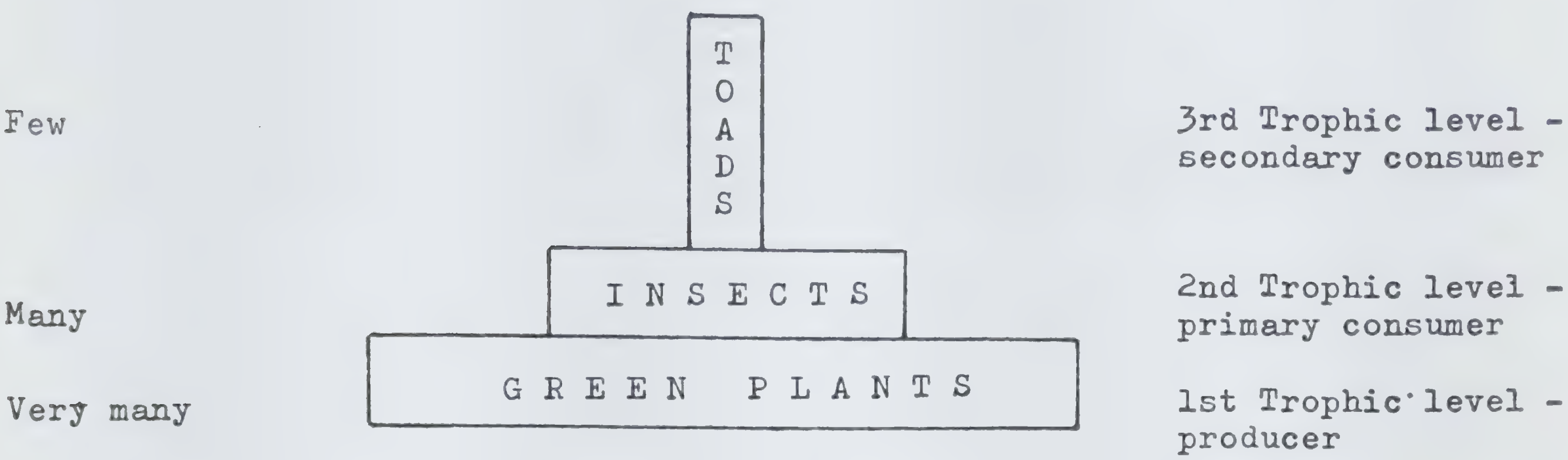


Figure 4: Pyramid of Numbers for a Simple Terrestrial Food Chain



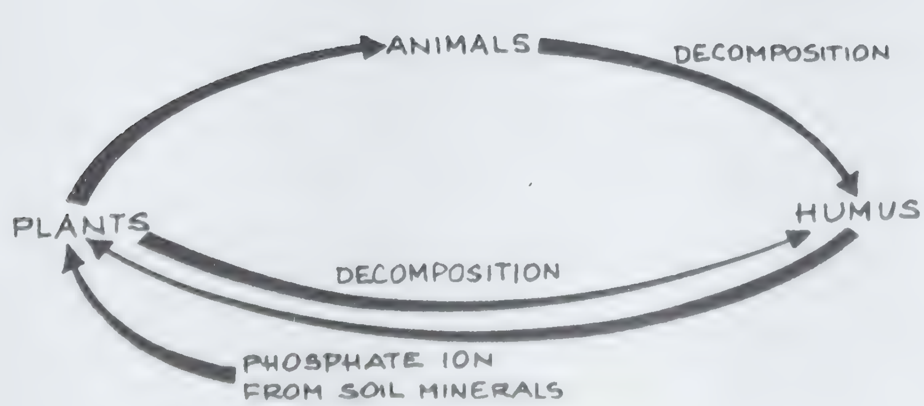
Cycle of nutrients

Available energy is a necessary but not sufficient input into the ecosystem or biosystem. In addition, there are the inorganic nutrients needed to build organic substances for the generation and regeneration of life. These organic substances eventually break down to release their inorganic components. Thus provision is made for their ready availability by a series of cyclic arrangements in nature. These biomechanical cycles are not entirely closed since some nutrients will be washed out of the soil by rain. They will, however, normally be replaced from rocks, dust, and in the case of nitrogen, by compounds washed down into the soil from the air by rain.

The cycles of greatest practical importance will be those involving elements which are rare in rocks, like phosphorus, or which form very soluble compounds, like nitrogen which may be easily washed out of soils. Supplies of these two chemicals are often deficient in nature.

Phosphorus is a component of the nucleic acids of living organisms, and of the high energy compounds which are essential to respiratory processes. The way in which it is cycled in nature is shown in Figure 5 below.

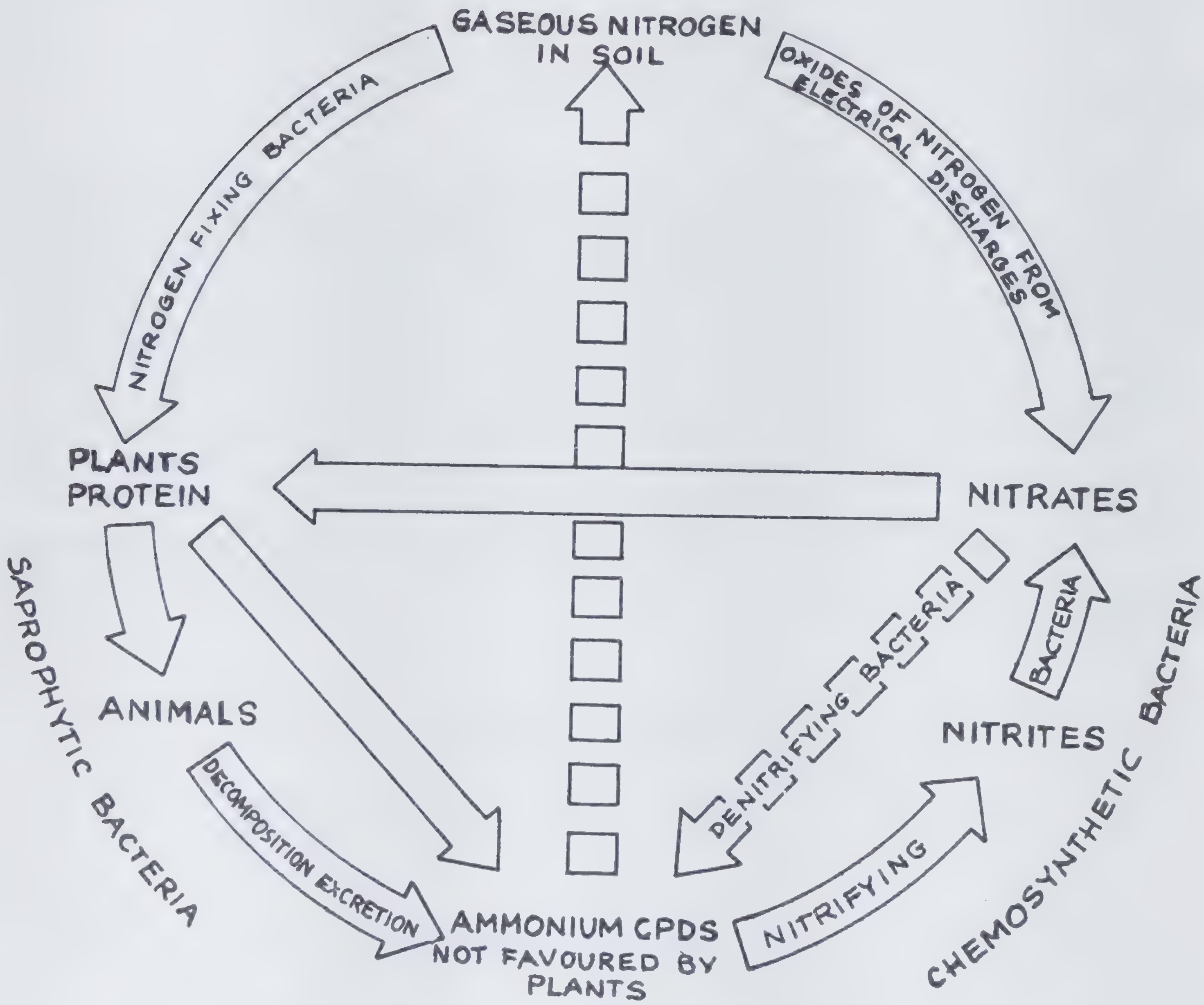
Figure 5: The Cycle of Phosphorus



Phosphorus is derived ultimately from calcium phosphate (apatite mineral), which is not only rare in rocks, but insoluble, forming ions very slowly. These may, however, form sparingly soluble compounds with iron and aluminium, which are often present in tropical soils. Plants may obtain some of their phosphorus from these compounds, but by far their most important source is humus. It is important to note that, unlike nitrogen and carbon, phosphorus probably is not involved in a natural cycle to replenish the supply of phosphorus in an ecosystem.

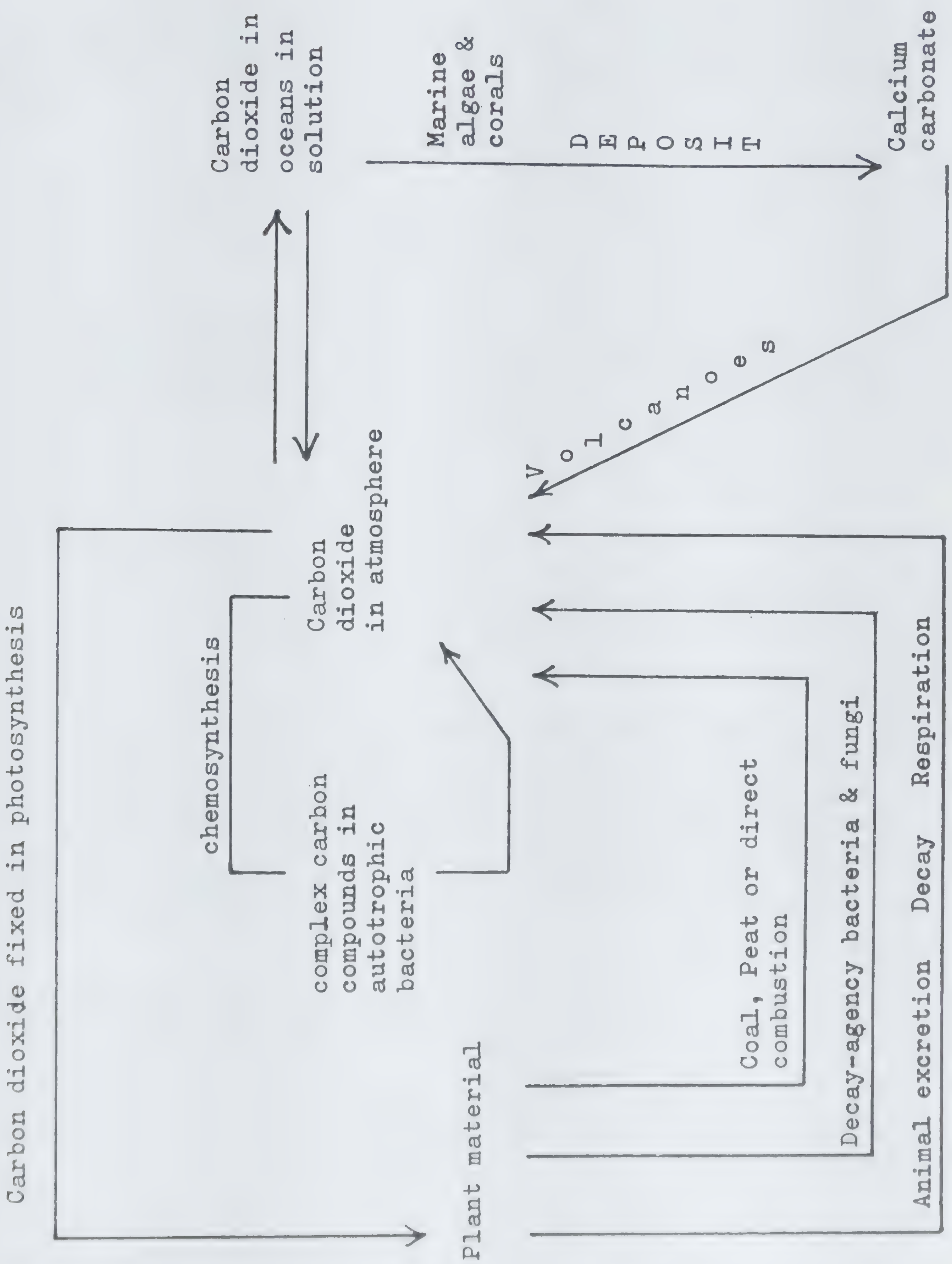
The Nitrogen Cycle. Nitrogen is an essential constituent of protein which is the basic matrix of living protoplasm. Figure 6 illustrates how it is recycled under natural conditions.

Figure 6: The Nitrogen Cycle



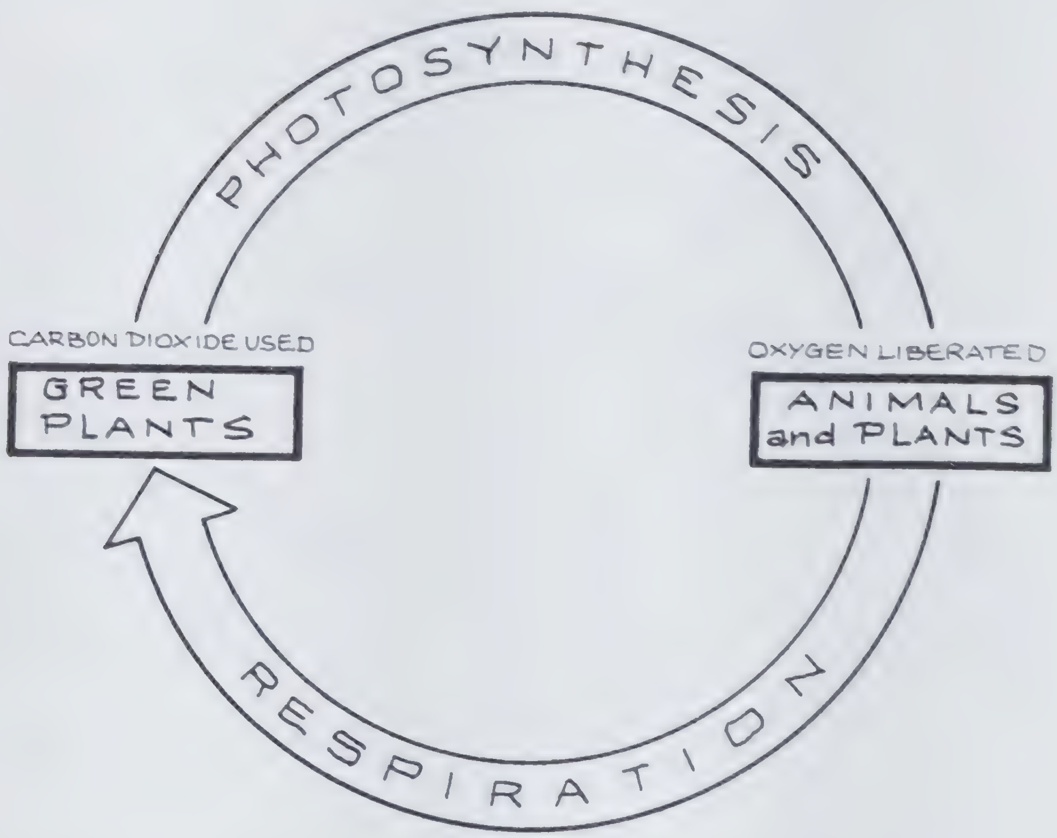
Carbon compounds are the basic repository of the energy fixed in photosynthesis. The pathways through which this element is recycled are shown in Figure 7. The main cycle is from carbon dioxide to living matter and back to carbon dioxide, but calcium carbonate rock built up by marine organisms represents storage.

Figure 7: The Carbon Cycle



Most organisms also need free energy for respiration, for which the reciprocal nature of the processes of respiration and photosynthesis makes provision, as illustrated in Figure 8.

Figure 8: The Cycle of Free Oxygen



Additionally, oxygen appears in many chemical forms and combinations, as in water, silica and other rocks.

The water necessary for the existence of all life is also cycled in nature, as shown in Figure 9.

In the natural undisturbed state, these cycles will continue to operate continuously so that a sufficiency of the materials they circulate is ensured.

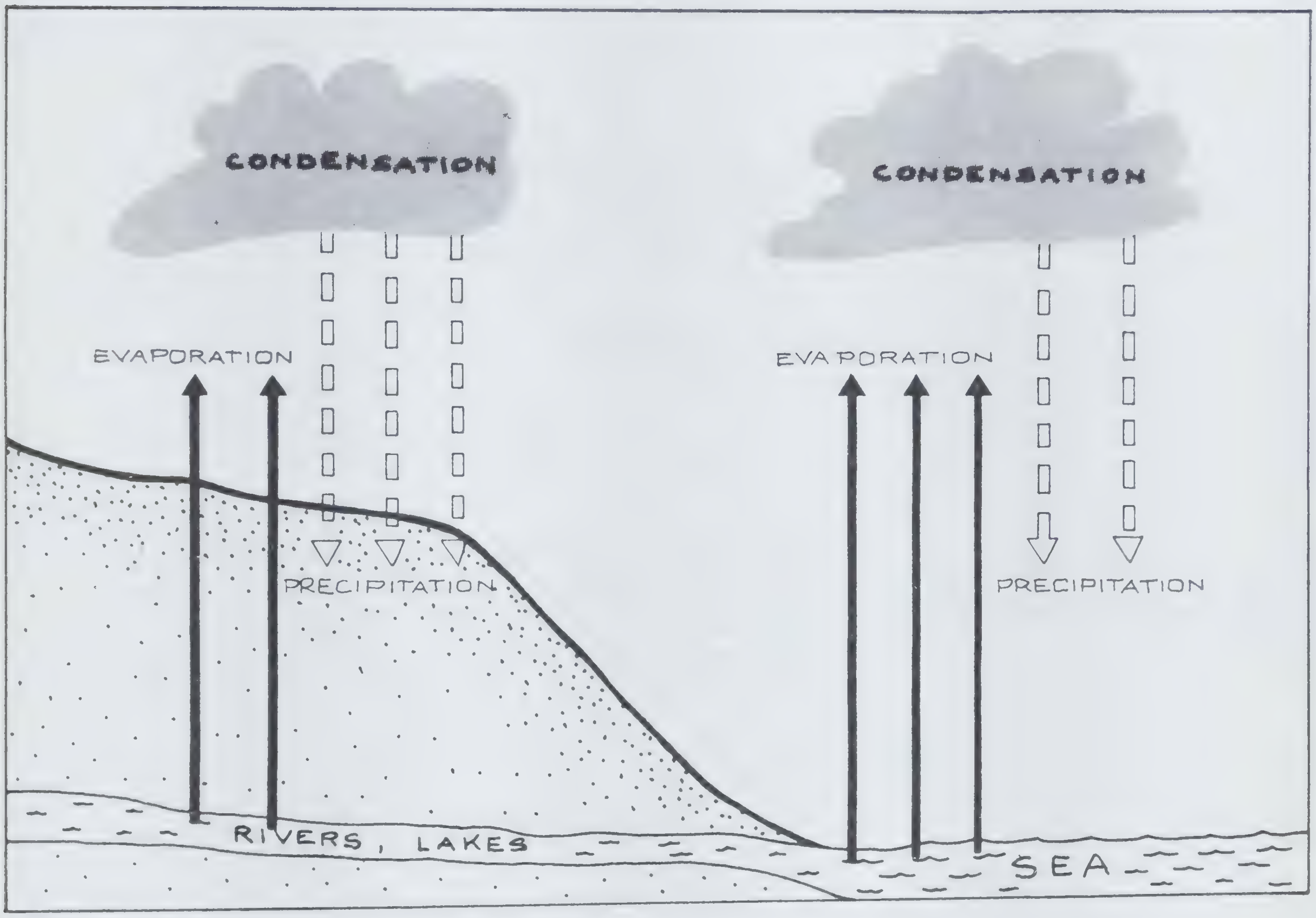
Ecosystem interrelationships exist at several levels of organization. The largest and most nearly self-sufficient of these is the *biosphere* or *ecosphere*. It includes man, interacting with the physical environment as a whole

> so as to maintain a steady-state system intermediate in the flow of energy between the high energy input of the sun, and the thermal sink of space
>
> (Odum 1971, p. 5)

The 'steady-state system' refers to the tendency for biological systems to resist change and remain in a state of equilibrium, a phenomenon known as *homoestasis*.

In practice, homoeostasis results in minimum fluctuations about a given norm through a built-in self-adjusting mechanism. The latter responds to a change in the environment by initiating corrective measures which work in a direction opposite to the change, and thus result in re-instating the norm. This is known as *negative feedback*. If the corrective mechanism breaks down, deviations from the norm lead to further deviation; this is known as *positive feedback*.

Figure 9: The Water Cycle



The latter could lead either to the establishment of a new equilibrium level, or eventually to death. Figure 10 below illustrates these principles in a general way.

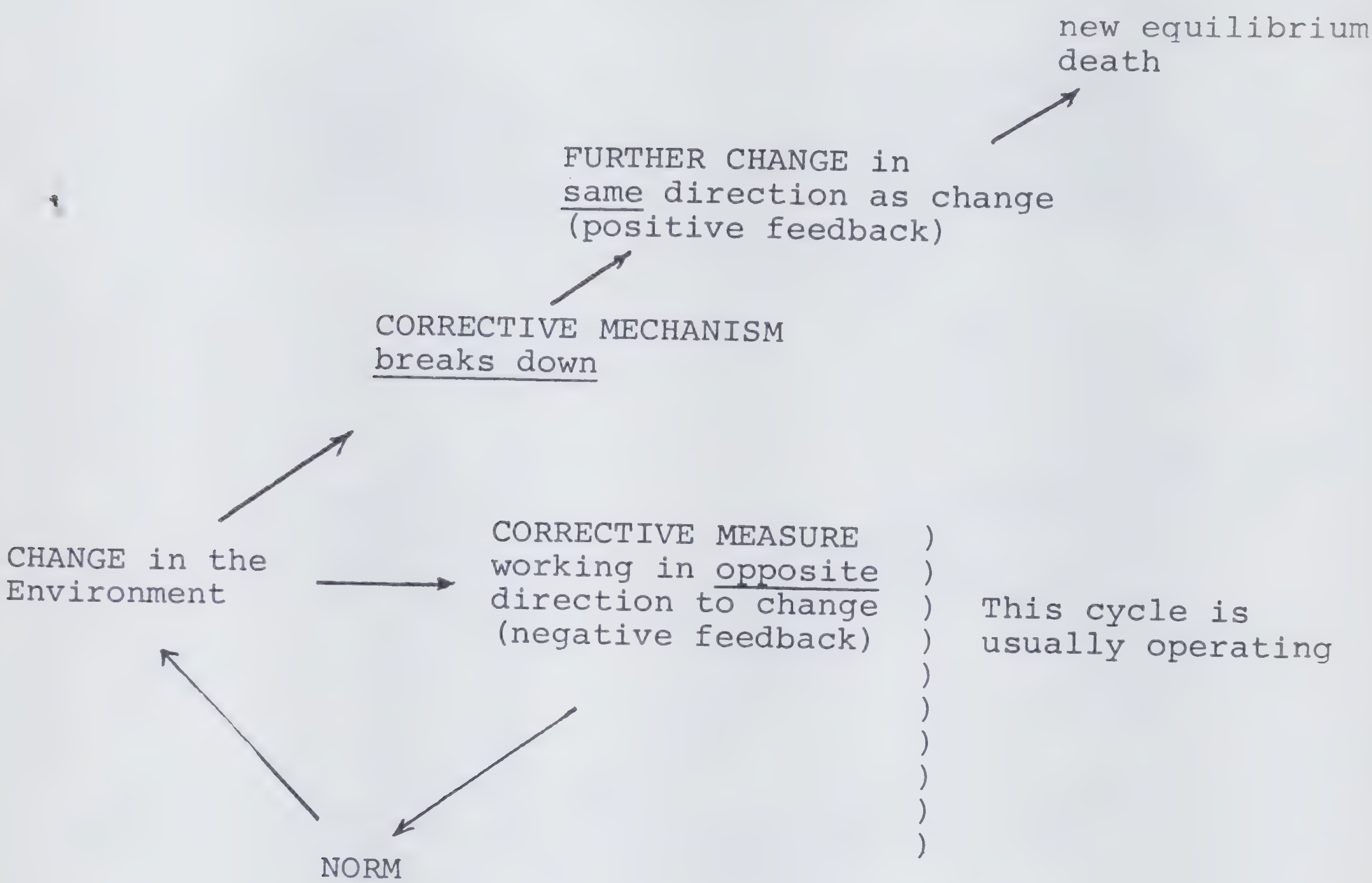
Newer ecosystems tend to be less well controlled, and to be more subject to outside influences. On the other hand, mature systems wherein the components have had a chance to make mutual adjustments to each other over evolutionary time are stable. Therefore, for overall maintenance of the biosphere, the several types of ecosystems within it should form a balanced pattern.

Ecological succession

Basic to an understanding of varying levels of maturity in ecosystems is the principle of ecological succession.

When development begins in an area which has not previously been occupied by a living community, it proceeds in a series of **stages** towards the establisment of the most suitable life forms and interrelationships which the physical environment permits. These comprise the *climax community*. The process involves continuous changes in species structure and *community dynamics*. Climate may be said to define the absolute potential for the climax community in any particular area, that is, by setting the limit to the light, warmth and water available, it also sets the limit to the complexity and numbers of living organism which the area can support. On a global scale in fact, climax climatic terrestrial formation types, typified by their vegetation

Figure 10: Basic Principles of Homoeostasis



are recognizable. These are outlined in Table 2. The vegetation, which represents the photosynthetic productive capacity of the system, will determine the animals which it can support.

The influence of climatic factors is, however, modified by other more localized factors. In a terrestrial ecosystem, soil and physiographic characteristics will act in this way. In a freshwater ecosystem, the nutrient supply may be the modifying factor.

Whatever the situation, one important characteristic of this seriation is that although the physical environment sets the upper limit of development and influences the pattern and rate of change, the environment is, in turn, modified by the community. For example, stoloniferous grasses may be the first colonizers of an area of bare land. As these plants die, and humus builds up in the soil, it becomes more capable of holding water, its mineral content is improved, and it becomes capable of supporting more productive vegetation.

Seriation is not confined to terrestrial ecosystems. The oceans, speaking broadly, presently represent mature steady systems, although increasingly their 'steady state' is being disturbed by pollution. Freshwater systems are much more fragile or easily upset, as well as smaller and less permanent in nature. Therefore it is easier to recognize stages of ecological succession.

Some freshwater systems are free flowing, e.g. rivers, springs; others are still-water systems, e.g. lakes and ponds. Whatever their nature, they interact intimately with the terrestrial systems around them, for example, with respect to the amount of organic matter they contain. Human settlements have also always been designed with a view to accessible fresh water supply, and there-

TABLE 2

CLIMATIC RELATIONSHIPS OF WORLD CLIMAX FORMATION-TYPES

Rainfall Decreasing →

Temperature Decreasing ↓

<table>
<tr><td rowspan="2">TROPICAL</td><td rowspan="2">Evergreen
Hygrophytic
Forest</td><td>Rainfall
Seasonal</td><td>Semi
Deciduous
Forest</td><td colspan="2">Monsoon Forest (Deciduous)
Deciduous Xerophytic Forest</td><td>Tall-Grass
Savanna</td><td rowspan="2">Desert Scrub

Thorn bush
& Cactus</td><td rowspan="2">Deserts
(Sandy Desert)
(Rocky Desert)</td></tr>
<tr><td>Rainfall
Distributed</td><td>Dry Rain-
fall
Forest
(Ever-
green)</td><td colspan="2">Dry Evergreen
Woodland</td><td>Dry Evergreen
Scrub</td></tr>
<tr><td rowspan="2">WARM TEMPERATE</td><td rowspan="2">Evergreen
Hygrophytic
Forest
(See note)</td><td rowspan="2">Evergreen
Mesophytic
(Conifer and
Broad leaf).</td><td>Summer
drought</td><td colspan="3">Evergreen Xerophytic
Woodland (Mediterranean)</td><td rowspan="2">Desert Scrub
(Thorn Bush
and Cactus)
Desert grass</td><td rowspan="2">Desert</td></tr>
<tr><td>Summer
Rain</td><td colspan="2">Tall Grass
(Steppe)</td><td>Short Grass
(Prairie Veldt)</td></tr>
<tr><td>TEMPERATE</td><td>Evergreen
Hydrophytic
(Broad leaf conifer
and mixed).</td><td>Deciduous
Forest
(Broad leaf).</td><td colspan="3">Mixed
Forest
(Conifer and
Broad leaf).</td><td>Conifer
Forest
(Northern
hemisphere).</td><td>Grassland
Tall or Short</td><td>Temperate
Desert scrub</td></tr>
<tr><td>BOREAL</td><td>–</td><td>Deciduous
Forest</td><td colspan="3">Mixed
Forest
(Conifer & Broadleaf).</td><td>Conifer
Forest</td><td>High Mountain
Grassland & Scrub</td><td>Tundra
(Cold desert).</td></tr>
</table>

fore, these systems have for a long time been subject to man-induced stress. There are also large numbers of man-made lakes and ponds.

The physical limitations in these systems where the medium is water, not air, are not only different, but in a sense much more finite since the systems are so discrete.

Light, temperature, oxygen — both the absolute supply and the balance with carbon dioxide — and nutrient supply are important factors which determine and regulate the interactions in the system. The depth to which light can penetrate determines the depth to which there is photosynthetic productivity. This in turn influences the amount of oxygen present in the water at any specific time, but the absolute amount which could be available depends on how much can be held in solution. This amount, even under very favourable conditions, is less than one per cent of the total volume. Oxygen is essential, for the respiration of the living organisms, except for some species of the fungi and bacteria which decompose dead plants and animals.

Carbon-dioxide, on the other hand is very soluble in water, therefore is never in short supply, and is more likely to be in oversupply as an end-product of respiration and decay processes. The gas is also obtainable from the pool of carbonates in the system.

Temperature affects the vertical movement of water in ponds/lakes and hence the cycling of nutrients which are concentrated in the mud at the bottom.

Figure 11 following, illustrates the generalized structure which would obtain in a relatively undisturbed pond. Succession is towards the filling up of the pond.

Acquatic animals include free floating planktonic forms, larval and adult forms of insects, crustacea, amphibia and fish. Some animals, e.g. some insects, 'visit', and remain on the surface of the water.

i) Open water represents the 'youngest' stage. The products are free floating algae (photoplankton) which disperse themselves as far down as light is available
ii) next is a region of totally submerged plants, rooted and with narrow elongate leaves
iii) this is followed by an area of rooted plants with large floating leaves which have elongated, flexible petioles
iv) a reed zone comes next; these plants are rooted under water, but much of the stems and leaves are above the surface
v) finally there are the marsh plants which bridge the gap between aquatic and terrestrial systems; they need a moist environment, but can stand some drying out. If climatic conditions permit there might be zones of shrubs and trees.

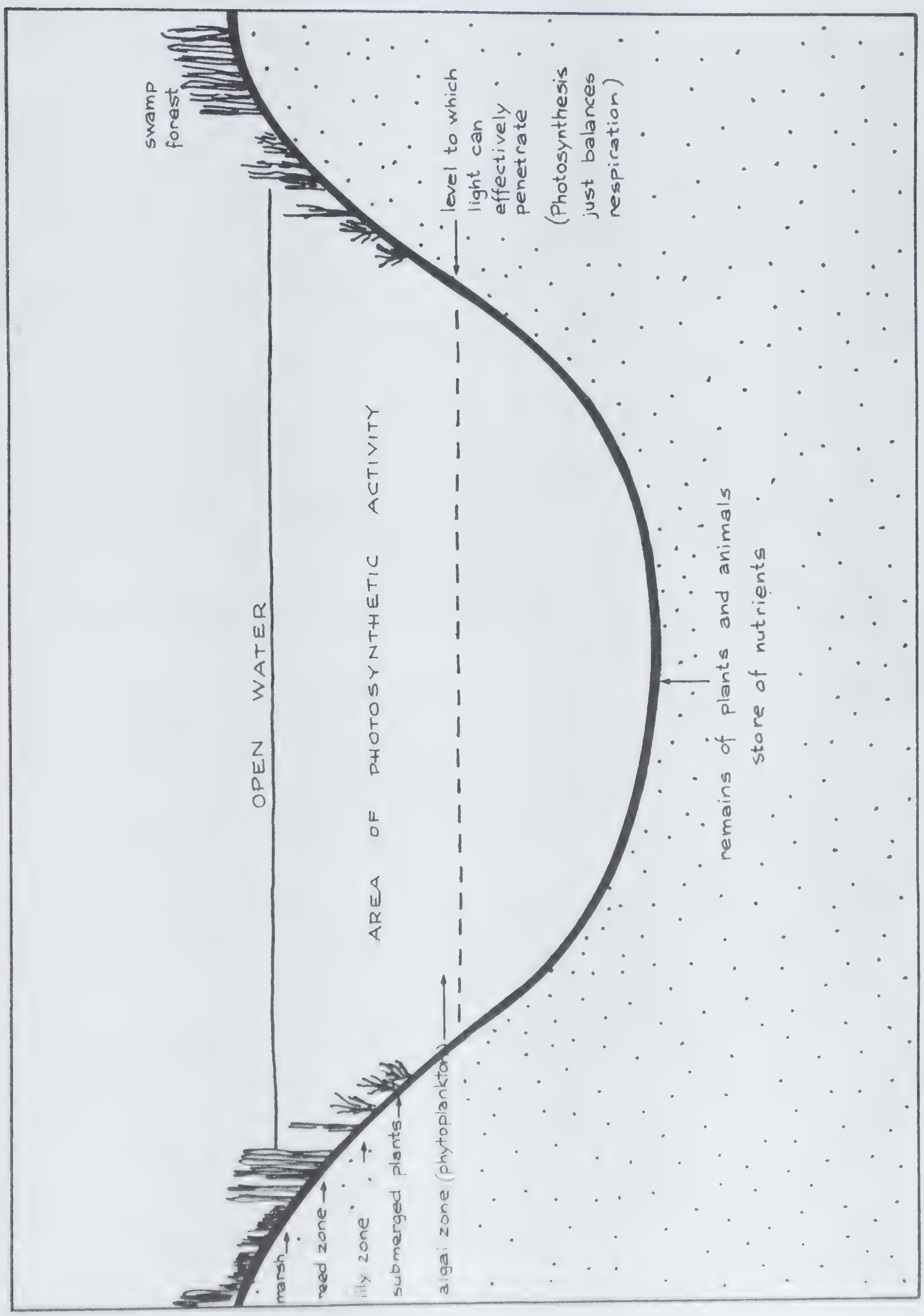
Associated with all of these zones are the consumers, the animals. Herbivores include free-floating zooplankton and swimming organisms such as tadpoles. Secondary and tertiary consumers include amphibians, fish, insects. Stems and leaves of rooted plants provide additional habitats. Some animals are detritus feeders, and can live on the bottom of the pond.

As animals/plants die, they fall to the bottom of the pond, providing a substratum for decay organisms and a storehouse of nutrients which are circulated by currents and swimming animals. The inflow of nutrients from the drainage area around the pond adds to this store and is a major influence on the stability of the system.

Overall, certain trends seem to follow the development of ecosystems from the early stages to the climax. These include:

a. a balance between the energy fixed by the producers in the system and that lost in the respiration necessary to maintain the system
b. a shift from a predominance of the simpler linear arrangements characteristic of grazing food chains to the more complex weblike relationships of the detritus pathways
c. high species diversity, and an increase in symbiotic relationships between species
d. increased capacity for trapping and holding nutrients for cycling within the system

Figure 11: Generalized Structure of a Freshwater Pond



All these make for increasingly stable relationships within the systems, a situation which reaches its maximum in the climax community.

Although seral stages refer to changes over time within a particular system, it is sometimes possible to have represented in juxtaposition a series of climax communties because of the ways in which local limitations present themselves. For example, the sand dune cactus/thorn succession seen in the coastal lands of many Caribbean islands represents one such series. Figure 13 depicts the typical seriation which might be found in such an area. Here the vegetation is zoned because of the different sets of conditions of stability of soil, salinity and wind effect which occur within a relatively small area, as distance from the sea increases.

Ecosystem development may be stopped or reversed by incidents of stress within the system. These may be natural, e.g., forest fires, floods, or on a gentler, more regular basis, by the movement of the tides. Man-induced stress has, however, the most seriously consistent impact — system development is not only stopped/reversed as in the clearing of forest areas to plant food crops, but may be changed in direction to produce completely new types. The urban eco-system for example, is one such type created by man.

On a global scale, Simmons (1977) has classified the ecosystems in the natural world into four main types:

— *Non-vital systems* (non-productive) e.g. very barren deserts, ice caps (although these are reservoirs of water).

— *High productivity systems at an early stage of succession:* these are unstable systems with low species diversity. Some systems are kept continually at this kind of developmental stage by external stress. Intertidal zones and estuaries are good examples of these systems; they are kept relatively fertile by the tides, which also provide the energy for rapid nutrient recycling. The species which exist in these systems have, over evolutionary time, become highly adaptable to the periodic disturbances.

— *Compromise areas* are approaching, but not yet at maturity. Species diversity is high, and the linear grazing food chains typical of earlier seral stages give way to complex webs of interdependence among organisms.

— **Mature systems** are the areas of climax vegetation (see Table 1). As has been indicated earlier, these are stable systems, characterised by intricate food-energy-nutrient relationships, where loss of nutrients is low and resistance to external disturbances high. There is a great variety of species, therefore these systems are important storehouses of biotic diversity. They also have a protective function in that they maintain global stability. For example, tropical rain forest areas are a vital factor in the formation of oxygen and the regulation of the temperature of the earth.

The open oceans also form one of these mature protective systems. They control climate, slow down and control the rate of decomposition and nutrient regeneration, thereby creating and maintaining the highly aerobic terrestrial environment to which the higher forms of life, including man, are adapted.

Man-made systems parallel these four types. The 'built environment' of urban and industrial areas are non-vital systems. Photosynthetic productivity, and the accompanying release of oxygen are at a minimum. At the same time both the oxygen requirements of the large population for respiration and the energy requirements for city living (electric stoves and other domestic units — air conditioning and heating units, transport and garbage disposal arrangements) as well as for factory complexes, are immense. Precipitation is quickly removed in the city — by drains if it is in the form of water, by shovels if it is in the form of snow. Thus, for its continued existence, the city is heavily dependent on the unbroken inflow into the system of energy, water and oxygnen from other ecosystems.

Further emphasising the parallel is the fact that heavy climatic stress is associated with both

tundra and desert, and is also evident in cities. It is known, for example, that over cities every major aspect of climate is different from that prevailing in the surrounding countryside. There is less sunshine, a lower relative humidity, more mean precipitation (although fewer rainy days), more cloudiness, less mean windspeed, more fog, and higher mean temperature (Lowry 1974).

Unstable high productivity systems in nature are supplemented by inputs of energy and nutrients such as is provided by the tides in the example above. Monoculture systems of agriculture like those of sugar cane, bananas, wheat, parallel these systems. Similarly, therefore, they require regular supplements of energy, in the form of work, and nutrients which are often supplied as chemical fertilizers. Species are selected for their qualities of rapid growth and high yield, rather than for overall contribution to the ecosystem. Man's distinct intention is large profits or, translated into biological terms, high net productivity to increase his food supply.

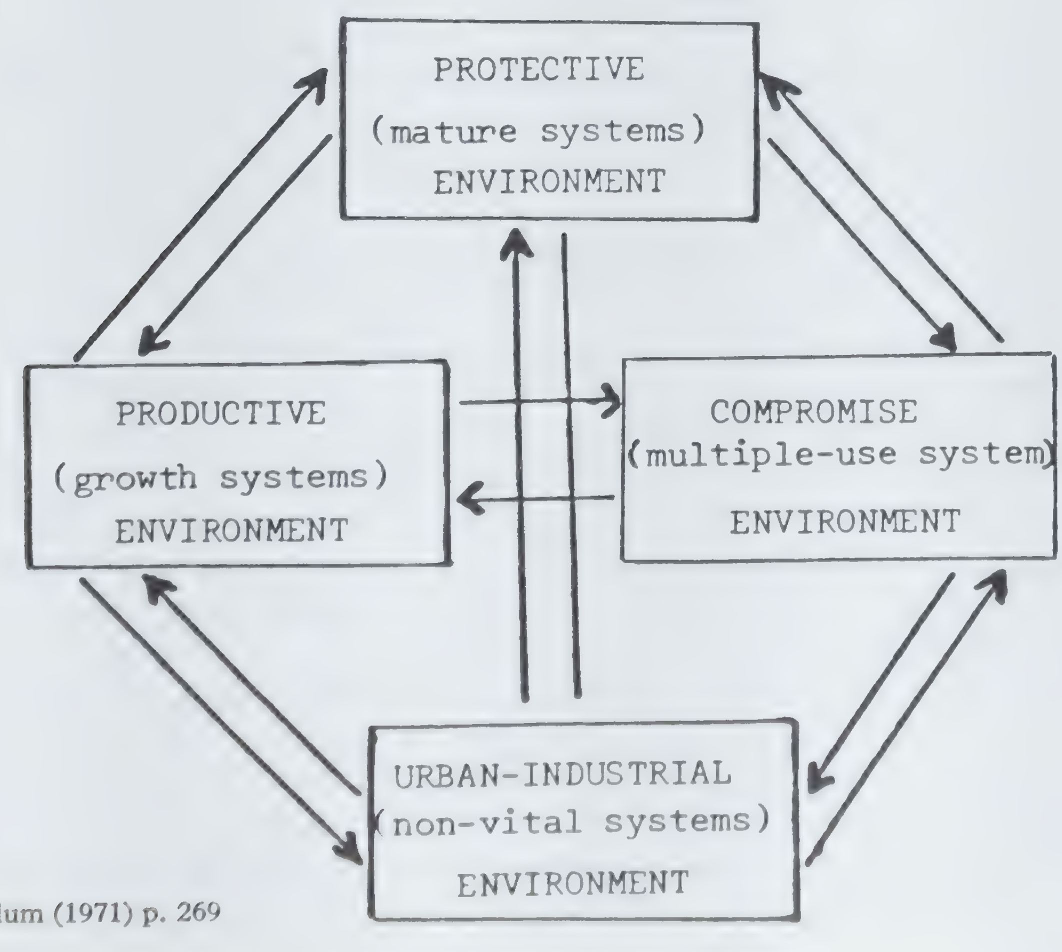
Where farming strategies attempt to take into account natural systems, a compromise may be effected between quantity of yield and quality of the environment. For example, on level areas with good agricultural soils, the simple precaution of crop rotation or strip-cropping can result, not only in the sustained productivity of agricultural crops, but in the increased species diversity and better cycling of nutrients which make for maturity and stability of ecosystems.

Some agricultural ecosystems which have been built on a principle of multi-use have evolved over long periods of time into what might now be termed *mature systems*. Those of Western Europe are an oft-quoted example.

In nature, there is a mosaic of the four types of ecosystems. Since a return to pre-agricultural existence is neither possible nor desirable, man must be aware of natural patterns in order to maintain long-term stability of the biosphere, while he seeks to satisfy his needs.

A conflict arises because ecosystem development in nature evolves in the direction of maxi-

Figure 12: The Basic Kinds of Environment required by man, partitioned according to ecosystem development and life cycle resource criteria*



*Source: Odum (1971) p. 269

mum protection for complex biosystems, that is, towards the development of mature systems. Man, on the other hand, aims at maximum production which favours the existence of younger, unstable systems. It is the more mature systems, however, which maintain the gas-exchange and nutrient recycling functions which are essential to the continued existence of life.

Odum (1971) suggests that there are two ways of rationalizing the conflict. There can either be a continual compromise between yield and quality of living space, or there can be deliberate compartmentalization, where the four types of systems are kept discrete, but so planned, that the productive systems do not expand beyond the capacity of the protective systems to balance them. The latter strategy affords a way of parallelling nature as mentioned above. Figure 13 depicts Odum's compartmental model.

It would seem that if the strategy is to be applied, there need to be certain operational "rules" in order to simulate the natural mosaic in man-made ecosystems and so achieve overall equilibrium.

It has to be accepted that existing man-made ecosystems present a four-fold picture:

a) some (e.g. cities, spacecraft) where many changes are irreversible and the trend of development needs to *continue;*
b) others in the process of being created, where it is still possible to change direction if advisable (e.g. new cities being developed)
c) others (e.g. monoculture agricultural systems) where change is desirable and possible
d) still others (e.g. oyster culture farms in Japan) which have evolved in the direction of nature, and need to be studied for use as models. Planning to deal with systems of types (a), (b) and (c) will, therefore, be different.

Since it is difficult to foresee in the short term some of the long term effects of change, *conservatism* in introducing new measures should be the policy.

Many of nature's most successful interrelationships have evolved in the direction of symbiosis or living together in mutual benefit. The association of green algae and coral polyps, or of leguminous plants and nitrogen-fixing bacteria are good examples. If the strategy is to work, then man's social systems must also evolve in this way — in other words, there has to be international cooperation.

A consideration of cities of types (a) and (b) as suggested above may serve to illustrate some of the principles involved in adapting the model.

The situation of climatic stress existing over cities has already been mentioned. The effects are the combined result of several factors. The compactness, irregular shape, and rock-like structural materials of the buildings and pavements result in the trapping and storage of more heat than in the countryside. At the same time the energy demanding activities mentioned also cause the generation of much heat and the release of large quantities of particulate matter and gases which change the air. The speedy removal of rain and/or snow also means that the cooling that would have resulted from their evaporation is lost to the system.

The sort of measures which might improve these conditions would therefore, imply for type (a) systems the setting aside of large tracts of land to lie fallow, and in a sense provide opposing type environmental influences to those of the city. At the same time technological innovations in manufacturing processes and intracity transport systems might help to reduce the emission of undesirable substances into the air.

Urbanization is growing in all countries and cities of type (b) could introduce into their planning phase deliberate strategies which would help to align them more with nature. For example, the architecture of buildings could be planned in tune with the landscape. Open "spaces" could be included in the city design. Legal sanctions could be imposed to ensure that the containment of particulate matter is a part of the design of manufacturing processes. Within certain limits, individual transport units might be forbidden, and a well regulated intracity

system worked out using fewer units and causing less noise and emission of poisonous waste.

The world's population must be fed, therefore organized agriculture is essential. This means a continuation of the deliberate development of unstable systems, but along lines which simulate nature. The periodic recurrence of gentle external stress which is nature's way of generating these systems needs to be studied, and the principles followed. Cultivated models are provided, for example, by the flooding, draining and soil aeration practised in the cultivation of rice.

The above suggestions are all technologically realizable. Whether these or similar type strategies are implemented will depend on man's attitude — on how much he wants this to be a reality.

Population dynamics

A *population* consists of the individual of a specie in an ecosystem. These population are in a constant interplay in response to stimuli — the urge for continuity of the species, competition for food, water, oxygen, light and predator-prey relationships.

Continuity is ensured by reproduction, with population size depending, in the first instance, on the ratio between the numbers of new individuals produced (natality) and of those which die (mortality). In animals, these numbers may be further temporarily or permanently modified by immigration (one way movement in) and emigration (one way movement out). Determining the absolute numbers possible at any one time, however, are various environmental factors, which in natural systems act collectively as a curb to prevent unlimited population growth and to keep numbers below the point which the environment can maintain (carrying capacity) indefinitely.

Physical factors like climate act as agents of gross control and may also produce unusual, temporary variations from the 'norm'. For example, drought or floods may destroy whole ecosystems by removing the food supply. On the other hand, an unexpected combination of good water supply and warmth could mean a temporary upsurge in food available, and a corresponding upturn in a population of herbivores which may 'overshoot' the normal capacity of that ecosystem for that species. Man-introduced measures like spraying against specific pests and diseases may also be regarded as gross control factors.

The agents of finer control which regulate the quantitative relationships between populations within a community seem, however, to be biotic factors, although always it must be borne in mind that these operate within, and interact with, the physical environment.

Social behaviour of different kinds also provide regulatory mechanisms. Well known is the behaviour of many birds in which individuals 'defend' territory they have 'acquired' against other members of the same species, thereby preventing overcrowding. Some animals on the other hand, tend to exist in groups where different kinds of social behaviour and organization prescribes a hierarchy of dominance or preference. There will, for example, usually be a dominant male in a herd of deer. Social insects like bees and termites have a very complicated organization with division of labour and programmed coordination amongst individuals with different genetic potential — worker bees feed and protect the hive; a single drone (to the extermination of all others) serves for mating with the single 'queen'. Thus this kind of organization at one and the same time accomplishes the 'protection' of living together, and builds in mechanisms to control the production of different types of individuals within the population. Swarming in bees provides additional strategy for ensuring the continuation of the species and relieving overcrowding in any one population.

European lemmings in some years of very high abundance also emigrate in hordes, eventually to drown many of their number. Thus, there appears to be some mechanism within the population itself which is triggered off by overcrowding and which acts to relieve the population pressure. Snowshoe hares, for example, at peak density often die of 'shock disease'.

The predator-prey relationship not only exemplifies a link between two different populations but also serves as a curb on population growth and population movement. This is well illustrated in the realtionship between the Snowy Owl of North America and the lemming, which is its main food item. Every three or four years the lemming population reaches a peak in numbers followed by a sudden decline. The rise and fall in the numbers of the predator (owl) population follows that of the prey (lemming).

To ensure their supply of food and other necessities, some animals exhibit regular diurnal patterns of behaviour. Cattle egrets, for example, scatter to feed during the daylight, but collect to roost at night. The African olive grass snake and the house snake both feed on mammals, but the former is active during daylight, the latter at night. In the marine environment, many primary consumers (zooplankton) remain low in the water during the day and migrate vertically at night to layers nearer the surface to feed. Mosquito larvae in the tropics tend to remain near the ground during the day, and to rise at night.

In response to seasonal changes, whole populations shift to follow favourable weather and supply of food. The migratory movements of birds and insects across whole continents are well documented examples.

Another strategy for survival is the capacity of individual species to adapt to and exploit specific ecological niches (space for operating) within the environment. This capacity is very evident in birds. Species living in the same area rarely eat the same food, especially if it is scarce. Thus interspecific competition is reduced and diversification promoted. A classical example is provided by the finches of the Galapagos islands. From a single type of ancestor, as many as fourteen species have evolved, based on feeding and situational habits. There are seedeaters, fruit eaters, cactus feeders and eaters of small insects. Some feed on the ground, others on trees. The example of African snakes given earlier shows how one niche can successfully be shared by more than one species.

The principles of population dynamics found among other living organisms apply to man as well since he is a member of the biotic community. Cooperation and competition for the basic biological requisites — food, water, oxygen — form one area of interaction within and between groups. They extend into such associated areas as employment, education, recreational facilities, material possessions, fame, nationhood. Migration is intimately linked to the search for employment, education and a higher quality of life.

An analogy may be drawn between the behaviour of the lemming in overcrowded conditions and the destructive violence which often erupts in urban areas where overcrowding creates population stress. Praedial larceny in rural agricultural areas may also be regarded as a reaction to or symptom of population stress.

Tribal, national and empire boundaries may be regarded as 'territory' to be protected; offensive and defensive wars are the extreme expressions of invasion and protection. Associated with these political boundaries are economies, religions, ideologies which intensify conflict.

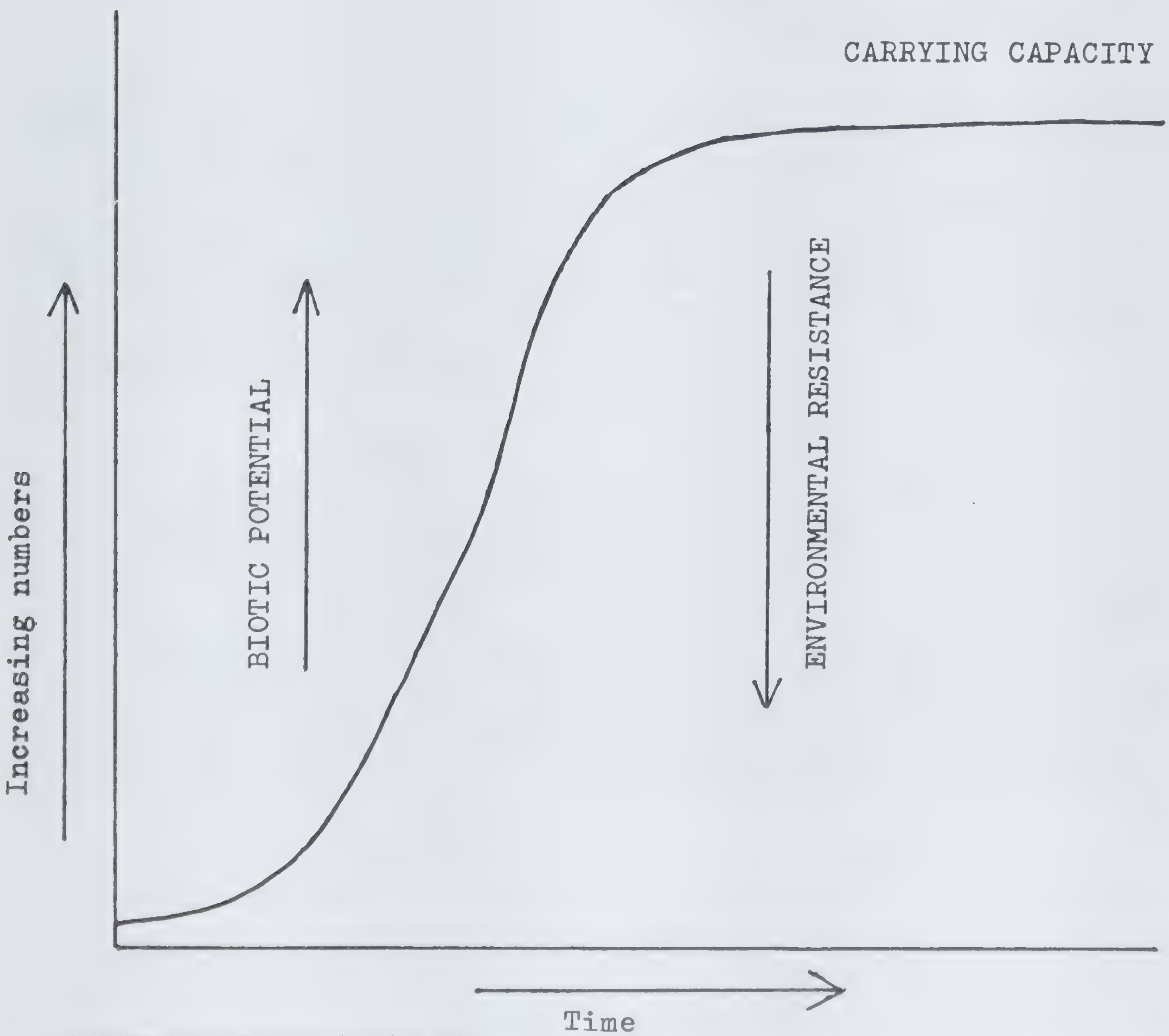
Within the family, the tribe, the community, the nation, the empire, are leaders responsible for certain areas of decision-making in the society and who constitute a hierarchy of dominance comparable to that in animal groups. In addition there are other forms of dominance – economic, intellectual, religious, aesthetic, judicial. All these influence the lives of populations both within and between societies.

In the case of economic dominance, the dominant 'rich' in any society openly or behind the scenes often influence strongly who the political leaders will be. They also determine the 'division of labour' in the society and this affects, for example population movements and distribution patterns. Thus the first line of workers — the workers in factory and field — tend to live in closest proximity to the workplace, causing heavy local concentrations of people. With progression up the ladder of management (more applicable perhaps to the factory situation) people tend to move

away from the workplace to have more living space. This creates the necessity for commuting, with its own set of environmental stresses — road building, traffic hazards, rush hours, atmospheric pollution.

The daily movement of people to and from the workplace is a regular diurnal pattern which is much more aggressive and must have more impact on the total environment than similar food gathering movements of other animals.

Figure 13: Diagram Illustrating Population Growth Curves*



*Modified after Dasmann (1976) p. 220.

A comparable statement could perhaps be made about seasonal movements once practised by human populations e.g. Eskimos, Amerindians. Each year bands of these populations moved from winter to summer camps, the availability of food being a critical factor in selection of the summer camp. Today, the economies of a few nations have been built around the seasonal movement of holiday makers, but the long term implications for the human resources, physical resources of space, natural attractions, food supply may create stresses in the host environment. For example, 'native' sea food dishes which would serve an island population indefinitely, could be-

come unavailable in a relatively short span of time when they have to be prepared in enormous quantities for thousands of visitors. Care has to be taken to preserve the reproductive integrity of the fish and molluscs which are so desirable, or run the risk of their eventual extinction.

In summary, the basic strategy which governs population growth is the interplay between the reproductive potential of various species and the environmental resistance provided by the physical, biological and social factors, some of which were discussed above. This interplay determines the carrying capacity of the environment as is illustrated in Figure 13 below.
For any species to survive, it is essential that this carrying capacity be not exceeded — indeed, for optimum quality of life, it should not be reached.

The socio-cultural and economic components

The basic unit of the world's population is the individual. The individual is at one and the same time, member of several groups — household, school, community, nation, world. The individual is also involved in a complex of interactions between self and the biophysical components of the environment, and between self and others in his groups and other groups.

Interactions with the biophysical consist of activities designed by, and dependent upon man's non-physical self-intellect, emotions, beliefs. Cyclically, the activities create an environment climate which affects intellect, emotions, beliefs. In the word of Hutchins (1968)

> Man makes himself by making the environment in which he places the newborn (p. 23).

Interactions between the individual and his group, between one group and another are characterized by agreement, disagreement, by unities and conflicts, by peace and war, by justice and injustice, by fair play and foul. All these activities and interactions are grouped and labelled by terms such as social, political, economic, aesthetic, religious — summarily they are called socio-cultural.

Socio-cultural activities vary from group to group arising from the fact that small groups of humans were originally scattered over the earth in differing biophysical environments in which each learned to live. Human needs were essentially the same (food, shelter, clothing etc.), but the fulfillment of these varied with what the environment offered and with the customs of the group. Muller (1952) found that over the centuries there has emerged "...a fantastic diversity in designs for living..." (p. 56).

Such activities include food-getting; making buildings; developing technology in the form of tools, machines and instruments to facilitate the performance of tasks; maintaining good health and numbers; establishing morals and values; setting up political institutions; various types of communicative activities such as dance, music, drama, works of art and craft; recreation; and communication and transport. These activities overlap and interact with each other. For example, food-getting activities are intimately linked with technological development, transportation and commerce.

At an even more basic level the organization and distribution of the work which needs to be done to accomplish these activities affect the whole spectrum.

From the earliest times work was allotted on the basis of age, and sex and ownership determined the distribution of the fruits of labour.

Thus, work was divided by type between men and women, and by skill and energy demands between adults and children. Where land/factory is owned communally or cooperatively, the fruits of labour/profits are shared. Where ownership is by a single individual (with or without

family) then the land is worked by serfs/slaves/wage earners and the owner decides on the manner in which produce will be used/distributed. Following the development of industrial work, a factory enterprise might be owned by a single individual/family/group (company, corporation, cooperative). Type of ownership has become the main criterion of an economic system.

Interactions between the biophysical and socio-cultural components

> Man sees the world around him through the spectacles of culture, and nature is thus transformed into resources. (p. 25).

The above quotation from Simmons (1977) is a particularly succinct way of showing that the biophysical components of the environment described earlier take on quite a different character when they are viewed as the raw material for man's socio-cultural activities. It is from these materials that he draws support for his physical and non-physical self — for his body, mind and spirit. His activities, therefore, exert an influence on these systems, which result in change and cyclically change him. Thus, even in those situations which seem uniquely human — the expression of his intellect and spirit — the principle of interaction and dynamism which is fundamental in natural ecosystems still holds.

The biophysical components of the environment are now examined as resources for man's activities.

Plants and animals as food

Each of the four to five thousand million persons on earth needs food for healthful living. People must eat not only specific kinds of foods, but enough of each to maintain proper levels of growth, physical and mental activity. The choice of foods of different peoples is influenced by natural conditions, by economic and political considerations, sometimes by religious teaching. Food usually has a place in religious rituals and is an item of national and international trade.

To date, all foods are derived from living organisms — plants, animals, mirco-organisms.

Plants

Of the plants, the most widely used as sources of food are grains (cereals). These have been cultivated since the beginning of man's history of settlement. Every major civilization used grain as the main source of food, and cereals, along with potatoes, other roots, and tubers are still the world's basic foods. The most widely used grains are wheat, rice, corn; others used are barley, oats, rye, sorghum and millet. They are preferred food crops because they are easily produced, easily stored and easily transported. Also, since they are plants, they are at the first, trophic level in the energy flow from the sun to living organisms. Grains produce more food both in quantity and quality per unit of land and labour than most other crops. It is not, therefore, surprising that an estimated two-thirds of cultivated land is given over to cereals. Grains are either eaten directly by man, or fed to draught or food animals. It is estimated that most grain is used for animal food and, therefore, that less of their energy becomes directly available to man. Grains have also always been used in the distillation of alcohol for domestic and industrial use.

Major grains	World's Yearly Production in Millions of Metric Tons	Chief Producing Nations	Food Uses	Nonfood uses —
Wheat	42	U.S.S.R, U.S.A, India, Canada, Argentina	Bread, pastas, cereal, baked, goods, livestock, feeds, flour, candy, vinegar	Synthetic rubber, munitions, straw
Rice (wet)	340	Indonesia, China, India, Bangladesh, Japan	Cereal, flour, candy, vinegar	Cosmetics, glue, laundry starch. paste, vinegar, alcohol, straw
Corn (maize)	330	U.S.A., China, Brazil, Rumania, U.S.S.R.	Puddings, syrup, margarine, cornmeal, cereal products, candy, chewing gum, livestock feeds	Paints, linoleum, adhesives, felts, cleaning, compounds, plywood
Barley	190	U.S.S.R., Canada, France, United Kingdom	Cereal, malt, beer, livestock feed	Straw
Oats	50	U.S.S.R., U.S.A., China, Canada, Poland	Oatmeal, bread, cereal products, livestock feeds	Solvents
Millet	50	China, India, U.S.A., U.S.S.R., Zimbabwe, Nigeria	Flour, cereal, livestock feed	Animal bedding
Sorghum	50	U.S.A., India, Argentina, Nigeria, Mexico	Flour, cereal, livestock feed	Brooms, brushes
Rye	30	U.S.S.R., Poland, Federal Republic of Germany, German Democratic Republic	Flour, alcoholic beverages	Thatching, mattress, stuffing, paper hats

Adapted from Gross (1980) World Geography p. 232.

The following table summarizes the current production of grains in the world and the forms in which they are used.

Potatoes, several varieties of yams, sweet potatoes, cocoes, dasheen are roots and tubers used mainly in tropical areas. In addition, people eat selected fruits, roots, leaves, flowers.

Of the micro-organisms, the yeasts are used in baking, brewing and other fermentation processes, and in the preparation of food for livestock (e.g. silage).

It is important to note that the geographical distribution of these croplands dictates not only local feeding habits, but the flow of trade between areas. This distribution also has an effect on population dynamics.

Animals

Animals reared and used for food today include cattle, goats, sheep, poultry, pigs, fish. Hunters have bagged wild animals — reindeer, birds (doves and ducks), antelopes, buffaloes, and seals. Marine and freshwater animals (e.g. fish) and crustaceans (e.g. crabs and lobsters) are also important sources of food for man. They have remained largely uncultivated, man remaining dependent on nature for supplies.

Non-food uses of plants and animals

For protection
In order to survive, some of man's activities have been directed towards protection of himself against the elements, against other men, against diseases and disorders. He has used the plants and plant products to build shelter, sometimes combining these with the skins of animals. The latter have also always constituted an important item of clothing, while plants supply such important raw materials for clothing as cotton, linen, sacking.

Against his human enemies, he has, in the past created offensive and defensive weapons of wood and bone — bows and arrows, clubs, spears, shields; he has used the poisonous juices of plants to make his weapons more deadly. Present day man has used chemicals in the manufacture of explosives, and disease causing organisms in developing germ warfare.

He has also sought to protect his crops by using natural predators to eliminate pests. To protect himself against diseases and disorders, he has distilled medicines from plants and made charms and powders from the bones of animals. The discovery of some of these medicines (e.g. quinine, penicillin) have had a great impact on world health.

Other uses

Plants, animals and their products have figured in man's desire to travel over land and sea. Whole lifestyles have revolved around the use of the camel for desert travel, and of dogs on the ice. Early boats (some of which are still used in places for local fishing) were hewed from the trunks of trees, or made using wood and animal skins. Later boats and ships were made using wood and metal, and wood has remained an important component of ocean-going liners. From earliest times, man created musical instruments with the woody parts of plants, with dried fruits, with the skins, guts and hair of animals and in later times with the metals from the earth. For his art and craft he used the raw materials easily found — stones, shells, fibres of indigenous plants, bones, seeds, straw, clay, paints and dyes from soil and plants. Specialized equipment for games (e.g. bats and balls) has traditionally come from plant, animal and mineral sources.

Communication over great distances by telegraph and across time by permanent records on parchment or paper are also dependent on plant and animal products, while the excitement of the hunt or the quiet relaxation of fishing have provided recreation, as well as food, for man.

Animals and plants also have their place in legend, myth and story and have held privileged places in religion.

The production of cosmetics from plant material and the construction of edifices like the great wooden cathedral in Guyana, also testify to the part plants play in satisfying the aesthetic in man.

Nor must the important role of living and fossil plants in providing energy be forgotten.

The physical components as resources

Water

The peculiar importance of water as the medium in which almost all biological reactions take place, puts the consideration of water resources on a different plane to that of any other. An ensured suppply is necessary not only as part of the external environment of all living organisms, but as the most essential component of their internal environment.

Over and above its direct effect on his physiological processes, water has further significance for man in other areas which affect his living. Water for domestic purposes comes first to mind: for cooking, for washing, and for disposal of household waste and sewage. The demand will vary with lifestyle, but it increases with increasing urbanization. Factories also make a substantial demand on water resources, not only for the employees, but for the industrial processes which often require water of high purity. Thus industrialization also increases the demand.

Plants, like other living organisms, need water to survive. In order to try to ensure adequate food supplies, man has used his ingenuity to provide water that plants need through irrigation. Further, fish, crustacea and other aquatic animals used by man for food, depend for their continued existence on the maintenance of the quality and fertility of the bodies of water which are their natural habitat.

The natural boundaries provided by rivers, seas, oceans and lakes have also formed political boundaries, separating the people of communities. For early societies, these natural barriers were a protection against enemies, but from another viewpoint they hindered cultural exchange and promoted isolation of peoples. In time, however, and with improved technology, water has come to support forms of transportation and communication which link peoples of the world together.

The water wheel was one result of man's very early efforts to use the energy from an inanimate source to do mechanical work. Today, water turns the large turbines used to drive dynamos which generate electricity.

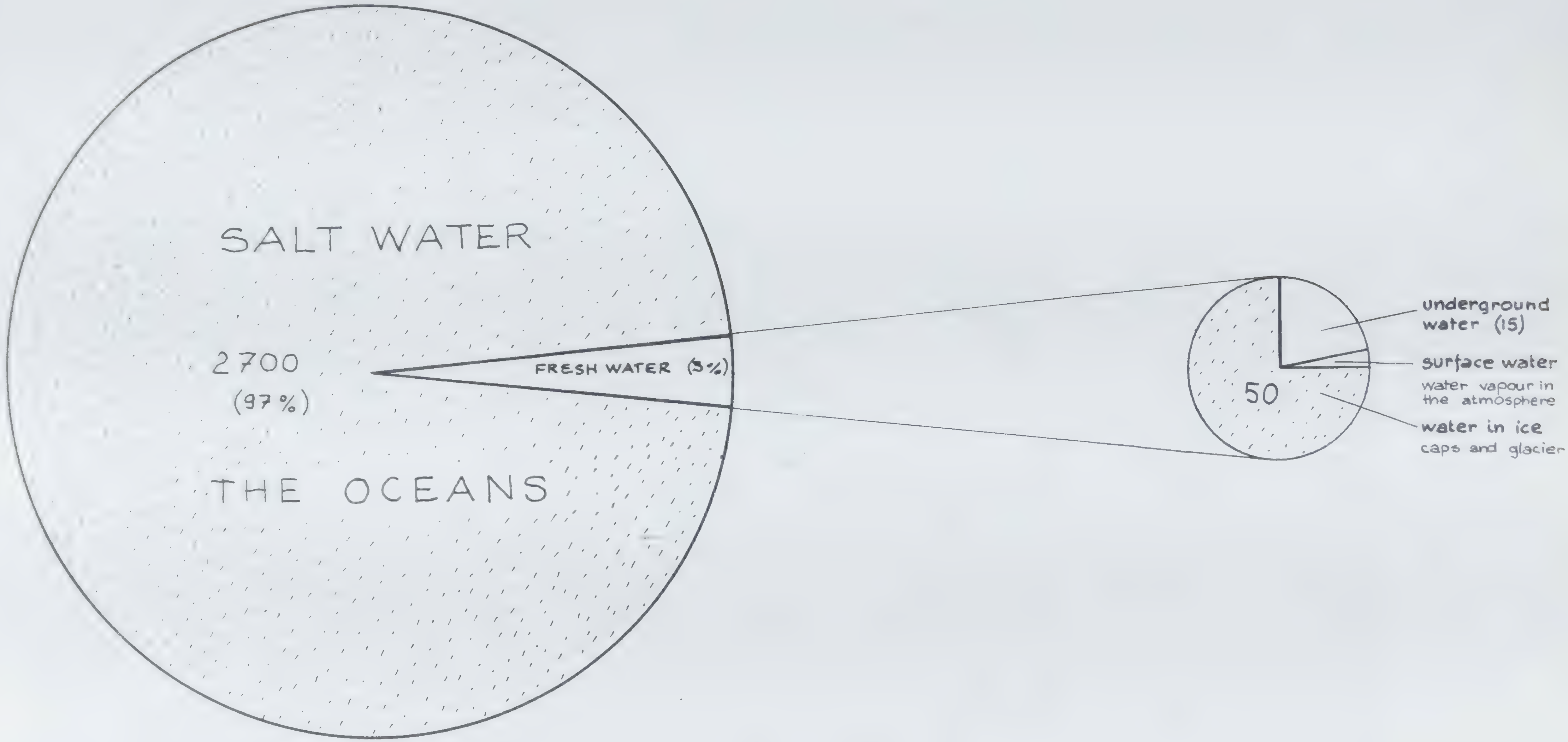
Water is also important in recreational activities; swimming, boating diving, water skiing, skiing on snow, skating on ice have all been for man's pleasure as means of dissipating aggressiveness through competition.

The water for all these activities is represented by a fairly constant quantity distributed globally, mostly in the liquid state, although there is some in the solid form and some as vapour. Its total volume has been estimated at 1,500 million cubic kilometres (1.5 billion U.S.) (Penman 1970). Of this 97 per cent is found in the oceans the greater part being in the Southern Hemisphere. Of the three per cent of fresh water, approximately three quarters is contained in ice caps and glaciers.

The rest is underground water, surface water mostly in lakes, and a very small, but important amount as water vapour in the air. The distribution is illustrated in Figure 14.

Atmospheric water vapour provides the weather changes which produce the precipitation for maintaining water reserves. The cyclic pattern of phenomena discussed earlier (p. 33 the water cycle) represents the through path for maintaining water supplies. Evaporation over the ocean is greater than return by precipitation, but the reverse is true of the land. Ice caps and glaciers

Figure 14: Diagram Illustrating the Quantitative Distribution of the Water Resources of the Earth



Note: The numbers (after Penman 1970) represent minimum estimates of the amount of water present in each reserve, expressed as depth in metres per unit area of the earth's surface (510 million square kilometres).

represent a store of water which may eventually melt and run off into lakes or rivers, returning eventually to the sea. Underground water may be taken up by plants and emitted into the atmosphere in the process of transpiration.

Minerals

In a very general sense, minerals may be considered to be substances obtained by mining. The fossil fuels, which represent organic material — the trapped remains of plants and animals in sedimentary rock — form an important group, which will be considered in the later discussion on energy.

The inorganic elements are found in varying amounts and in different combinations in the earth's crust. From man's viewpoint, abundance is not as important as the presence of the element in a form and at a geographical location where it is technologically and economically feasible to extract it. Aluminium and iron, for example, are not only abundant (8.13 and 5.00 per cent of the crust respectively) but exist in ore deposits which may have as much as 60% or more by weight of iron, and 20% or more by weight of aluminium. At the other end of the scale, copper, mercury, silver, platinum, gold are among those which are scarce in the crust — their abundance being far below 0.1%.

Of these minerals, man has used metals for a long time — so long that the capacity for working metals has been used as one measure of development. For example, one speaks of the Iron Age; indeed, iron has been said to be the very backbone of civilization — certainly it has been said that it accounts for more than 90% of metals consumed. Metals, because of their strength, lustre and powers of electrical and heat conduction are used in a host of ways by man. They are used for making ships, trains, cars, aeroplanes and other means of transport, weapons for defence, machines for industry and household use, packaging materials for food and other commodities, instruments, buildings.

Since the distribution of metal ores bears no relationship to the political boundaries of the countries needing to use them, metals have become articles of trade and provided, as well, an imperishable form of exchange for the barter system in the form of coins. Even where, for convenience, bills are issued as a form of exchange, these are supported on an international scale by reserves of metal (usually gold).

Many minerals are also essential for the growth and efficient functioning of living organisms. For example, man, in common with other animals with a skeletal framework, needs to have calcium and phosphorus for the normal development of this framework. A proper balance between sodium and potassium ions is necessary for the efficient functioning of his nervous system.

Plant growth requires nitrogen, phosphorus, potassium, calcium, sulphur, among other elements; for land plants these must be supplied by the soil in a form in which they can readily be assimilated. Arising out of these needs for organized and intensive agriculture, has emerged the use of chemical fertilizers in organized and intensive agriculture. Chemical fertilizers are needed, in part, because the system does not allow the wait-time for nutrients to be recycled naturally.

The three elements most in demand for these purposes are nitrogen, phosphorus and potassium. Much nitrogen is supplied through synthetic processes, but there are deposits of nitrates (as in Chile) which are mined. Phosphorus may be obtained from apatite and potassium from marine evaporates or accumulation of salts by evaporation of sea water.

Minerals are also used in industry as abrasives; diamond, the hardest known natural substance is heavily used as an abrasive. Other minerals find use in the production of paper, soap, detergents, glass, antiseptics and other areas of industry.

Building materials obtained from the earth's crust are also extremely important resource

materials. Stones, sand, gravel, crushed rock are used without further treatment in buildings and in road construction. Other materials like cement, asbestos, glass, bricks are processed from natural products, and acquire through processing, particular characteristics that are desirable. Asbestos, for example, is flame resistant, and is widely used in some building materials.

The skill with which man has used these building materials has been one way of leaving permanent records of his history in the environment as well as creating totally new environments.

Reference must also be made of the use of metals in medicine in the areas of radiology, X-rays and radioisotopes.

Energy

Essential for man's social, cultural and economic activities, even in the most primitive societies, are sources of energy. In earliest times, he relied exclusively on muscular energy generated from the food he consumed. Over time, he used the muscular energy of other animals, and invented simple machines which maximized the effectiveness of his exertion and/or lessened the physical demand on him.

Progress is linked with control over nature. Put another way, the level of science and technology attained by a society is used as the index of its development. Prosperity or economic health is gauged in terms of economic growth, in terms of gross national product (GNP). So both progress and prosperity are directly proportional to increasing use of energy.

In Figure 15 below, Cook (1971) has depicted graphically the change in energy demands of increasingly 'civilized' man. One important outcome of increasing demands is that man, in constant search for new sources of supply, has had to use what might be called in economic terms not only "income" or renewable sources like green plants or falling water, but "capital" sources like the fossil fuels which are only renewable in terms of millions of years.

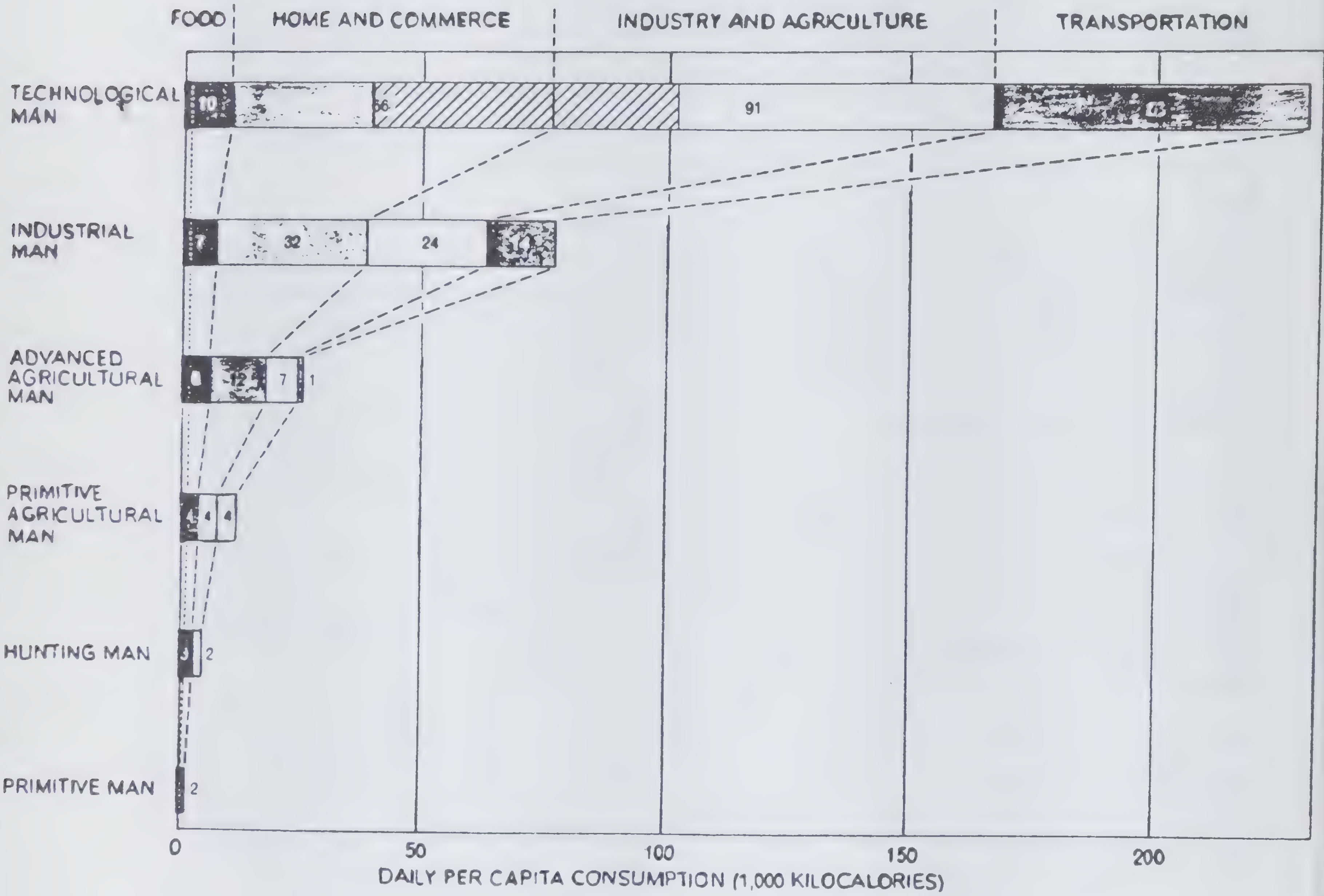
A consideration of the energy sources available for man's use illustrates very well the interaction among the biological, physical and socio-cultural dimensions of the environment. Sources may be biological or physical in nature, but whether they are available in terms of how to use them safely and responsibly is a function of the third dimension.

Energy for potential use, reaches the surface of the earth from three sources — from the rivers and tides, from the earth's interior. and from the sun.

Energy from tides

Tides are a result of the gravitational pull of the moon and sun, especially the former. The rotation of the earth on its axis causes two high and two low tides daily everywhere, but tidal heights are not all the same. In order to use the energy from tides, it has been found that in general, tidal heights of five metres or more are necessary. Some of water at the high tide must be stored behind barriers in order to be used to generate electricity on its release. The potential from this source is not great in a global context, but where the conditions favour its use, it could be of immense local importance. At La Rance in France, there is an output of 544×10^6 kilowatt hours (KWH) from a tidal range of 8.4 m; 320,000 KW from the 7 m tidal range at Lumborskya Bay, and another 1.3 million KW from a 9 m tidal range at Mezen Bay on the White Sea are planned by the Soviet Union. One advantage of this source is that it created relatively little ecological disturbance.

Figure 15: Daily Consumption of Energy *per capita* for Man at Different Stages of Cultural Development*



*Source: Cook (1971) p. 274.

DAILY PER CAPITA CONSUMPTION (1,000 KILOCALORIES)

DAILY CONSUMPTION of energy per capita was calculated by the author for six stages in human development (and with an accuracy that decreases with antiquity). Primitive man (East Africa about 1,000.000 years ago) without the use of fire had only the energy of the food he ate. Hunting man (Europe about 100.000 years ago) had more food and also burned wood for heat and cooking. Primite agricultural man (Fertile Crescent in 5000 B.C.) was growing crops and had gained animal energy. Advanced agricultural man (northewestern Europe in A.D. 1400) had some coal for heating, some water power and wind power and animal transport. Industrial man (in England in 1875) had the steam engine. In 1970 technological man (in the U.S.) consumed 230,000 kilocalories per day, much of it in form of electricity (*hatched area*). Food is divided into plant foods (*far left*) and animal foods (or food fed to animals).

Energy from the earth's interior

Small amounts of naturally occurring radioactive atoms are present in the rocks of the earth's crust, mainly uranium-238, uranium-235 and thorium-232. The heat from these fission reactions has accumulated over millions of years, and reactions continue. This heat reaches the surface of the earth through rocks, or rarely by outward flow of hot water. In a few places hot rocks are near the surface and geothermal pools or underground reservoirs of steam and hot water may occur. These may be tapped, and the steam used to generate electricity.

Larderal in Italy boasts a geothermal plant of 362 KW (1970); other plants include one at Wairiki in New Zealand (192 KW) and in Northern California, U.S.A. (192 KW). Although estimates of world potential are of the order of 60 times the existing capacity utilized (Simmons 1974), this cannot be considered a source on a world scale, although like tidal energy, it is of local significance where it is available.

Energy from the sun

More than 99% of the energy coming to the earth comes from solar radiation, but little of this is directly utilized as energy. Some 30% of this radiation is directly reflected. About 47% is converted to heat, which is absorbed by the oceans, the land and the atmosphere, producing winds, waves, ocean currents and weather patterns. Some 23% is utilized in evaporating water which falls as rain and snow, which eventually runs downhill back to the sea. Running water, is, therefore, one expression of solar energy. A very small proportion is used by green plants in photosynthesis.

Solar energy is therefore, used in various ways. Direct solar energy is used in a limited way for simple heating devices like water heaters and solar cookers.There are several indirect uses of solar energy:

Water power

As has been mentioned water power has been used for a long time in devices like the water wheel. The present century has witnessed the much expanded use of waterfalls and the artificial damming of rivers for generating electricity. Difficulty in utilizing this source may stem either from the distance of the source from human settlements, or from the unavailability of the capital required for development. In 1964, installed capacity was estimated at 210,000 MW or about 7.5% of the potential capacity. Water power is a clean and renewable source of energy, but damming rivers often produces undesirable ecological side effects.

Wind and ocean power

Wind power has long been used on a small scale. West Indian sugar factories were for many years thus successfully powered. Wind, is, however, intermittent and, therefore, not dependable enough for large scale industrial use. The thermal power of the vast oceans, and the energy in waves still remain to be tapped.

Chemical energy

Green plants capture solar energy by means of their chlorophyll, and convert this into the chemical energy of carbohydrates. This reaction is the most important for the maintenance of life as we know it. Not only is this the basic reaction by which food is produced, but the temporary storage of this energy in biomass is necessary for the maintenance of global ecosystem stability (see p. 41). Wood is also an instant (and renewable) source of energy, especially in the less developed countries. Longer term storage of this energy, over millions of years, is represented in the fossil fuels — coal, tar, oil, natural gas. These constitute the major source of non-nutritional energy utilized by man. Indeed, it is past exploitation of these resources and their current inability to meet the demands of technological man, coupled with their discontinuous global distribution, that has precipitated the present global concern about energy resources.

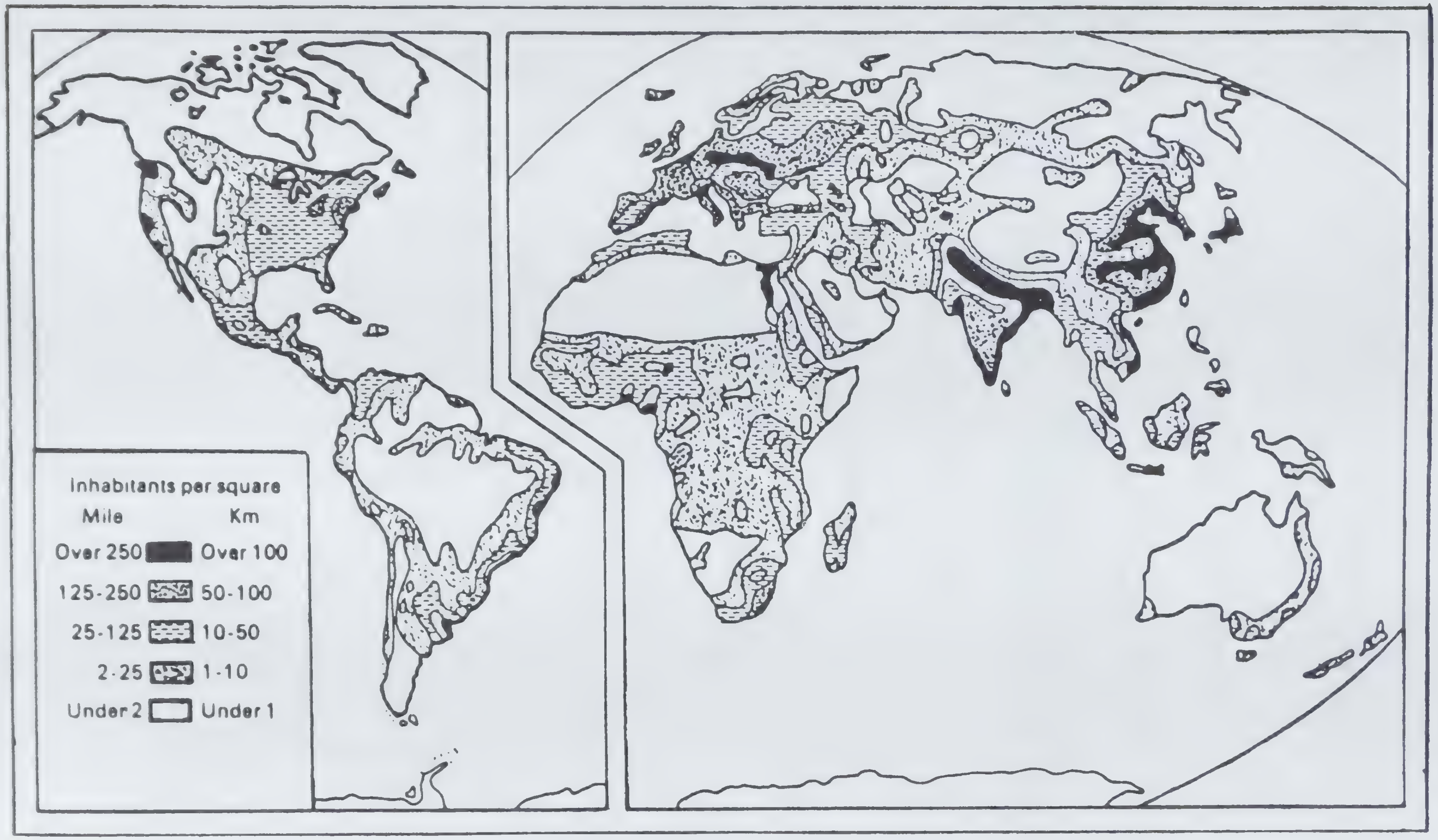
The kind and level of use to which these resources are put is both culture bound and intimately linked with the material affluence of a particular society. Both these aspects are, in turn, dependent on the style and intensity of scientific and technological development, since this influences a people's perception of their environment, their place in, and relationship with it.

Looked at from the viewpoint of material affluence, it is evident that most of the world's population which constitutes the poorer peoples of the earth is still using muscular power for agriculture, wood for fuel, simple boats for fishing. There are still today societies which function as primitive agricultural man on Cook's scale (see Fig. 15 above), and he estimates that the richer industrialized regions support only 30% of the world's population. The differences in life style also mean differences in the consumption of resources, the latter increasing with growing industrialization. Even within societies differences exist, and the lettered and the ignorant, the rich and the poor, live side by side.

Absolute numbers, as well as **patterns** of human population distribution are linked with the availability of natural resources. Gross distribution patterns have, like those of other animals, been tempered by the harshness of the physical environment. Ice-bound, desert and very high regions cannot support high concentrations of people: limitations of food, water, oxygen supply, temperature prevent this. Densities, therefore, remain low in these areas. World population distribution shows a preference for two types of situations — naturally favourable rural agricultural areas like the valleys of the Nile and Ganges rivers and maritime east Asia, and intensely used urban-industrial and agricultural areas as in western and central Europe. South-east Asia accommodates one-half of the world's population on one-tenth of the habitable area, and Europe (including European Russia) holds one-fifth of the global population in less than one-twentieth of habitable areas (Simmons, 1977). World population density is illustrated in Figure 16 below.

Any consideration of human populations must also recognize the presence of distinct groups and races of man since these have generated different cultures with the varying value systems and customs which exert their influence on resource utilization. These groups and races, which evolved in relative isolation, now interact on a global scale as communication has improved. Therefore they now see their aspirations not only in local, but in global context. The result is a tendency towards increasing resource consumption as the world's poorer peoples seek to model their life style on that of the richer.

Figure 16: World Population Density*



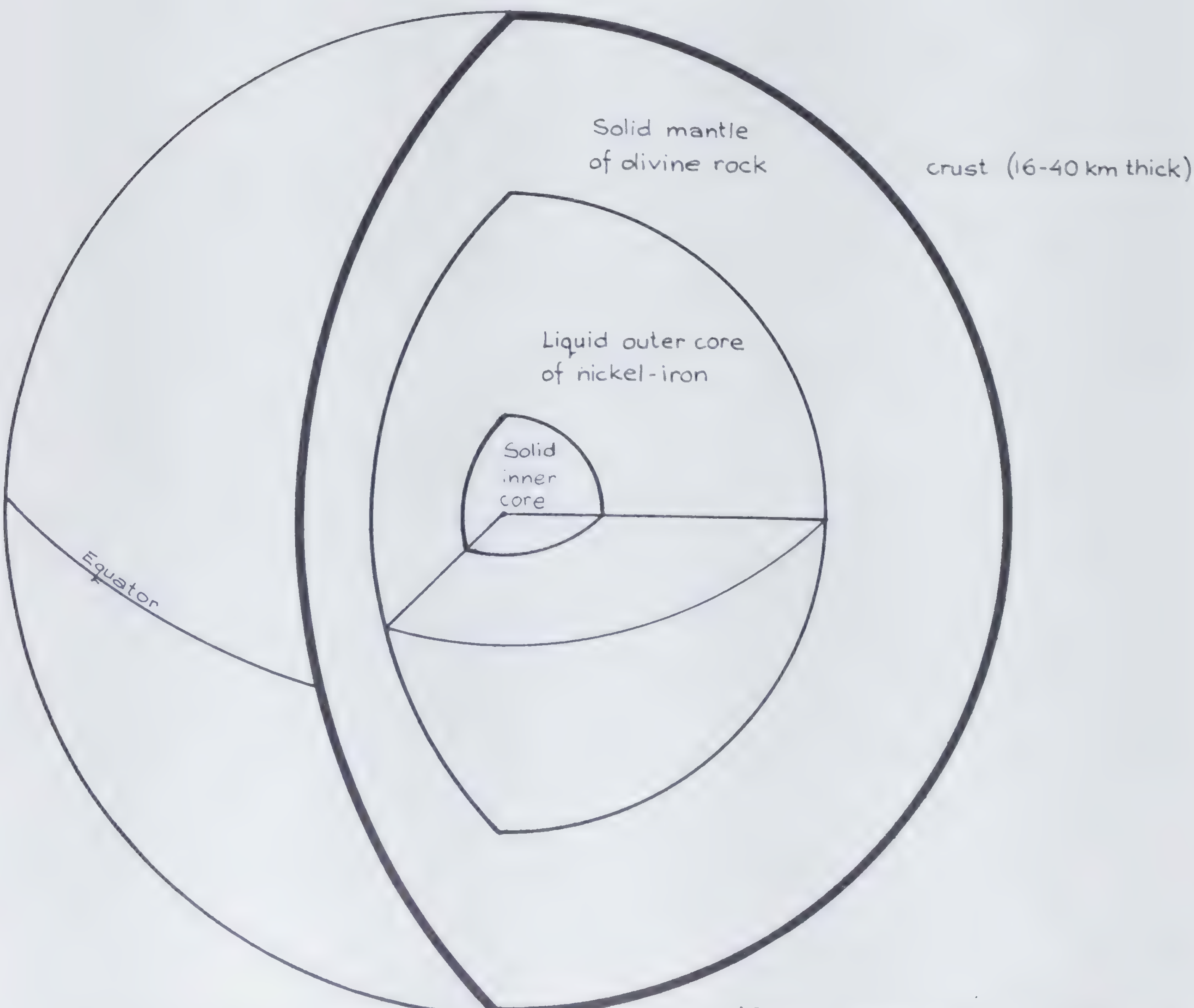
N. B. Rural agricultural regions, especially in Asia, and urban-industrial regions are very heavily populated.
*Source: Simmons (1977) Fig. 12.3, p. 329 (after Trewartha).

CHAPTER 3

Problems arising from interactions in the environment

Underlying all problems associated with the environment is one common denominator, namely, imbalance. The overriding characteristic of natural systems is their capacity to maintain

Figure 17: Structure of the Interior of the Earth*



*Source: Strahler and Strahler (1977), p. 143.

a steady-state or equilibrium. Interactions promote or limit each other in such a way as to maintain a situation in which there is harmony. Whenever this dynamic balance is upset, there is an environmental problem.

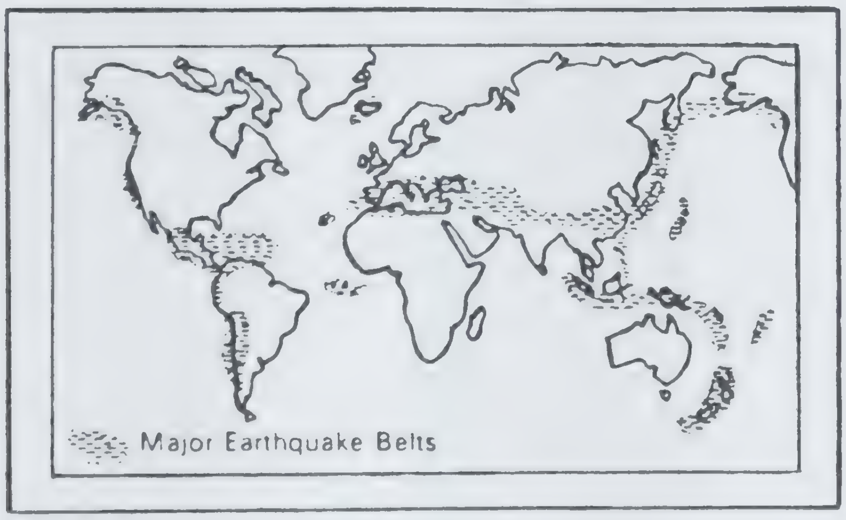
Many of these problems are man-induced, but many are, and arise out of naturally-occuring events. This chapter will attempt to consider some of both types of problems.

Some naturally-occurring problems

These include cyclones, tidal waves, floods, forest fires, earthquakes, volcanoes, drought, and epidemics. It is interesting to note that these 'natural events' are both the result and the genesis of imbalance, as will be illustrated in the examples which follow.

Illustrated in Figure 17 below is what is believed to be the internal structure of the earth. It can be seen that the crust constitutes the life supporting area. Earthquakes and volcanoes are evidence of strain in the earth's crust.

Figure 18: Major World Earthquake Belts*



*Source: Bunnett (1973) p. 32.

Earthquakes are sudden movements in the earth's crust. Vibrations moving out from the point of origin cause lateral and vertical movements which result in violent shaking. They are usually associated with faults or cracks in the crust resulting from collision between plates. In Figure 18 below are indicated the major earthquake belts of the earth.

Imbalance in ecosystems may be manifest in a number of ways after an earthquake. These include:

a) lateral and vertical displacement of parts of the earth's crust
b) tsunamis (seismic sea waves) resulting from the raising or lowering of parts of the sea floor. In Sagami Bay, Japan, parts of the Bay were lifted by 215 metres by earthquake activity in 1923
c) landslides
d) lowering or raising of coastal regions

e) fires
f) destruction of the arrangements for public health safety in human settlements, with the consequent multiplication and spread of disease organisms.

Volcanoes

Below the earth's crust, although temperatures are very high, the great pressure keeps the rocks in a semi-solid state. If the pressure lessens, as happens when faulting takes place, some of these rocks become liquid. This liquid may emerge at the earth's surface, when it is termed lava. Where it comes quietly out through a fissure, it builds up a lava platform or flow. Where it emerges forcefully by way of a vent, it builds up a cone-shaped mound called a volcano, the structure of which is simply illustrated in the diagram below.

Figure 19: Simplified Diagram of the Structure of a Volcano

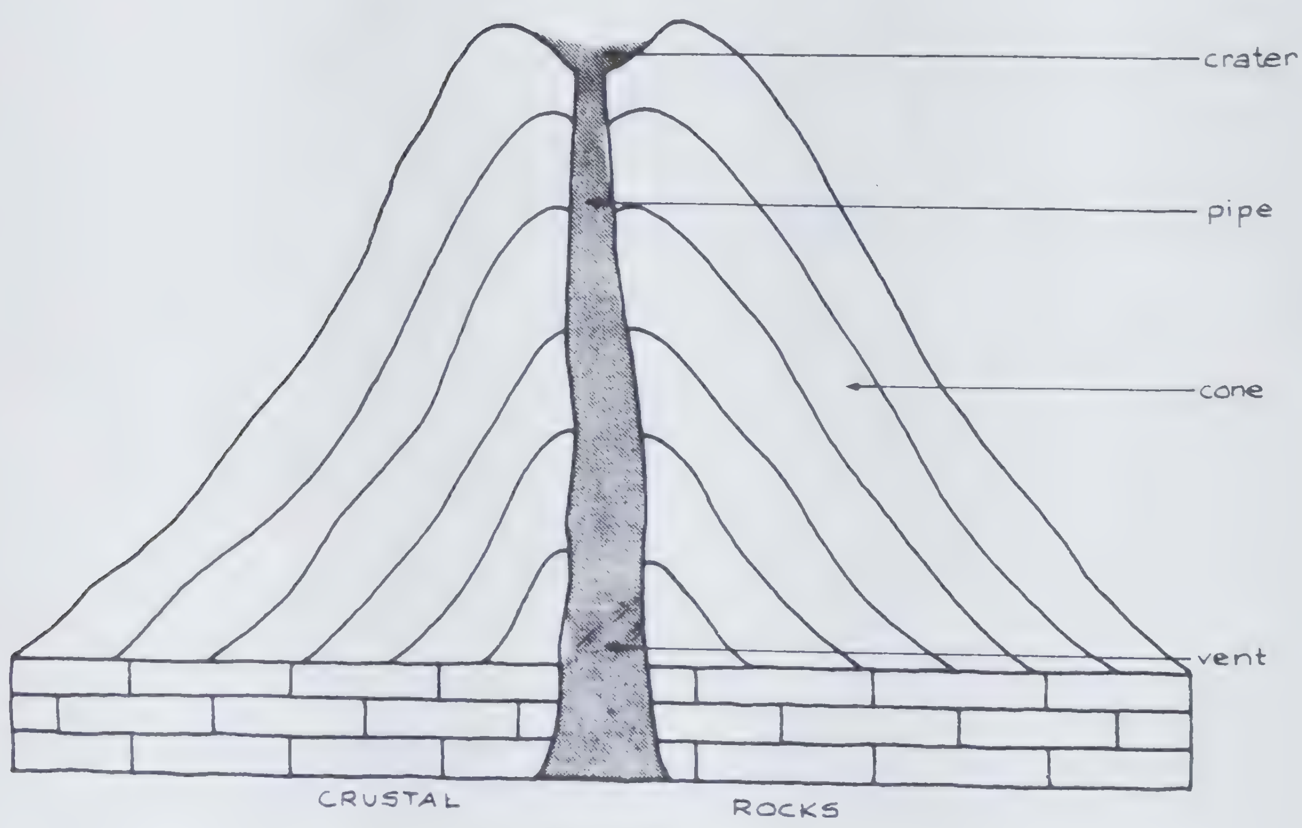
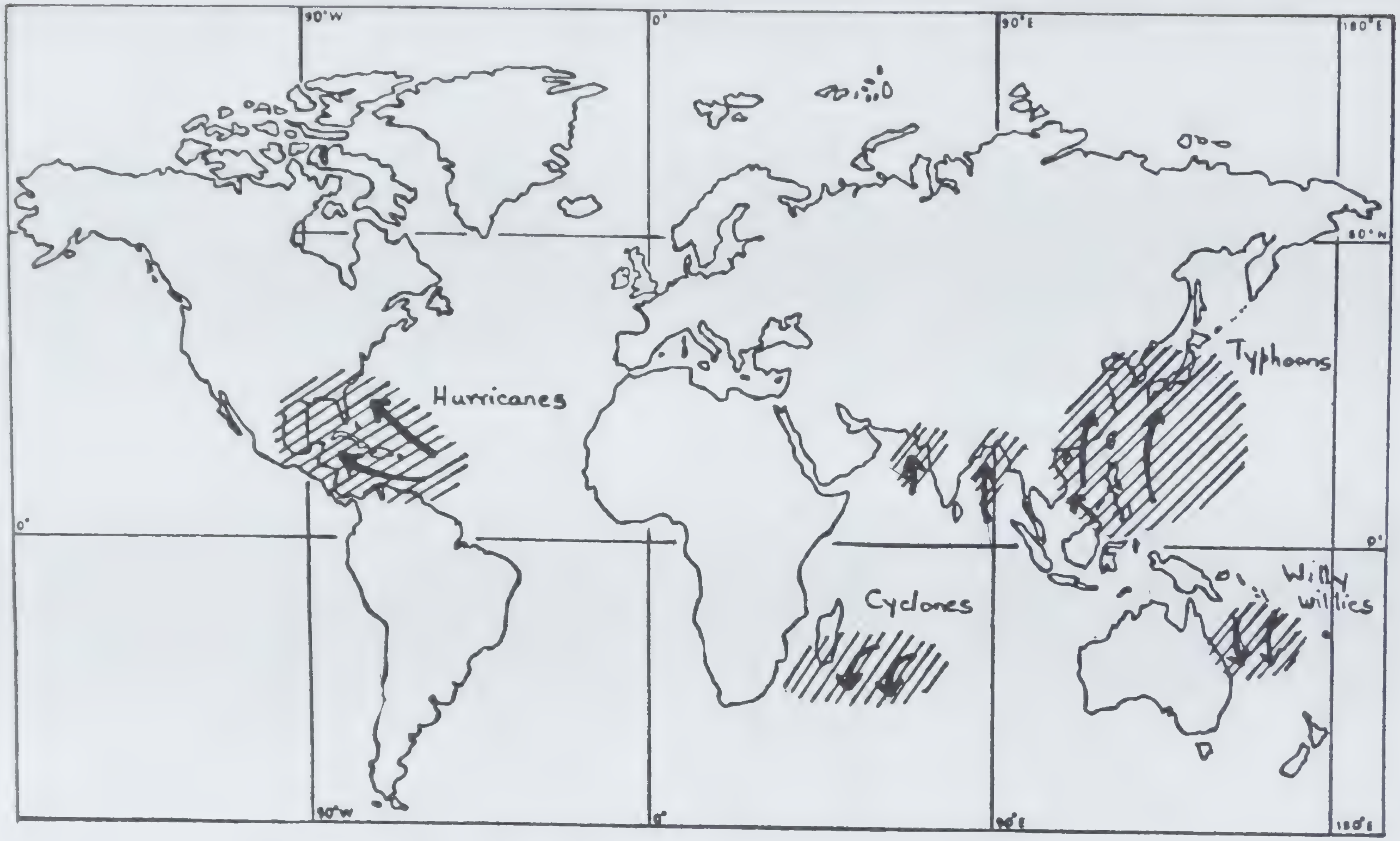


Figure 20: World Geographical Distribution of Regions Affected by Cyclones



Legend:

Tropical cyclones

Paths taken

Volcanic eruption cause great loss of life. Many of the gases burn with intense heat, and some, like the sulphur gases, form a dense cloud which rolls down the side of the volcano, killing anything in its path. Molten lava is also intensely hot; where it explodes violently into small pieces, these may be blown to great heights, and the fine dust or ash can travel vast distances in air currents.

Tropical cyclones

These develop over the oceans where the trade wind air masses converge. The lower layers of the air masses are moist, and the higher air masses are drier. Where two such air masses meet, one of them will tend to be lifted up, causing instability. The cyclone is an almost circular storm centre of low pressure around which winds are blowing at very high speeds. Dense clouds and torrential rain accompany the disturbances. As a cyclone passes, there is a period of calm with the arrival of the central 'eye'. After the 'eye' passes, the disturbances continue in like force, with the wind blowing from the opposite direction. Cyclones are termed typhoons in Asia, and hurricanes in the West Indies. Figure 20 below shows the main geographical areas affected by cyclones.

Tornadoes

These occur over the Mississippi Valley in the U.S.A. mostly, and differ from cyclones in that they originate over land. They are the smallest, but the most destructive storms known, with wind speed in excess of 320 kilometres (200 miles) per hour. Each appears as a dark funnel cloud hanging from a dense cumulonimbus cloud. Destruction is complete within the narrow limits of the path of the storm.

It is perhaps in the toll they take on human life and cultural resources that the consequences of natural disasters are most forcefully realized. Earthquakes have devastated cities, for example, San Francisco (1906); Napier, New Zealand (1931); Agadir, Morocco (1960). Landslides in China claimed the lives of 100 000 people (1927) and the lifting of the seafloor in Sagami Bay, Japan, 200 000 people (1923). In more recent times, 50 000 Peruvians were killed and one million left homeless by the 1970 earthquake. Cities have been buried by volcanic ash, as was Pompeii after the eruptions of Mt. Vesuvius. Mt. Pelée in Martinique destroyed St. Pierre (1902).

The circum-Caribbean area is particularly prone to natural disasters, situated as it is both on the hurricane and earthquake belts. The Dominican Republic (1946), Caracas, Venezuela (1976), Managua, Nicaragua (1931 and 1972), Antigua (1974), Guatemala (1976), Colombia (1979), have all had recent experiences of devastating earthquakes.

The slopes of active volcanoes in the islands of the Eastern Caribbean are more densely populated than similar sites elsewhere, and while it has been suggested that the risk to life would only be serious within ten kilometres of the erupting vent, indirect effects on agriculture would be evident over a much wider area. For example, St. Vincent lost its entire banana production in 1979 as a result of volcanic eruptions. In Guadeloupe, a major part of the Basseterre region has been evacuated following the 1976 resurgence of activity at the La Soufrière volcano.

Hurricanes are annual 'fact of life' in the region. Originating over the Atlantic or in the Gulf of Mexico, they follow certain tracks through the islands. A few may affect the eastern coast of the United States, but usually they die when they leave the tropics or cross the mainland of North or Central America. Hurrican Flora (1963) swept through Tobago, Haiti, Cuba, while its outlying winds and rain damaged Grenada, the Dominican Republic, Jamaica, the Bahamas — affecting

altogether about two and one half million people and killing over 7 000. Hurricane David completely devastated Dominica in 1979.

The area is particularly vulnerable to economic backlashes from these disasters because it is a series of small island states, where population increases have caused pressure on land resources, so that marginal coastal lands are being occupied for residential, commercial and even service installations, for example electricity plants.

Some man-induced problems

If one considers —

a. the structure and resources of the biophysical world

b. the way in which man consciously or unconsciously manipulates these to satisfy his way of life as prescribed by his socio-cultural and economic dictates —

it becomes evident that lines of stress are created for the former because of the latter. That is, problems arise out of the interplay of supply and demand for man, either directly or indirectly through other organisms. As Odum (1971) puts it —

> Until now man has generally acted as a parasite on the environment, taking what he wants with little regard for the welfare of his host, that is, his life-support system (p. 510).

Some of these problems will now be considered in relation to the needs outlined in. A the latter part of Chapter 2 (page 39). The overarching problem of human settlements and population growth weaves through the entire discussion.

Meeting the need for food

For the first two million years or so of his existence, man lived like other animals — as predator, herbivore, scavenger. Under these conditions the biosphere could support a human population of about ten million — less than the population of London today. Primitive tribal taboos — on hunting grounds, the prohibition of sexual intercourse for nursing mothers, headhunting expeditions, all helped to keep the population in check.

With the advent of the 'agricultural revolution' some 10 000 years ago, man became a tiller, and the limits on available food supply were reduced. Gradually primitive taboos were less rigidly enforced and eventually disappearing. The power structure changed to favour tribes with larger numbers. The domestication of plants and animals left the way open for unlimited expansion of the human population, and, like a vicious circle, the expansion of the population has meant the enforced increase in the production of food.

Man has tended to favour those species which may have been most useful to him in the wild — wheat, barley, sheep, goats, cattle, horses, etc. As a result, he has altered the composition of the world's plant and animal population. Crops replace original cover of forest or grassland; some 10 per cent of the total land surface (3 billion acres) is now under cultivation. Two-thirds of the cultivated cropland is given over to cereals. Cattle replace buffalo on the American plains and the kangaroo in Australia. Not only has relative abundance changed, but the exchange of crops between the Old World and the New since the fifteenth century, has meant that global distribution has changed as well. The potato went from South America to Europe, soybean from China to the United States of America and the USSR, the breadfruit from Tahiti to the Caribbean.

In addition, sheer greed has led to 'overhunting' and the consequent extermination of many species e.g. the bison. Others, like the white whale, the rhinoceros of Africa and Asia, are currently in danger of extermination. Natural food chains have been upset.

At the present time, organized agriculture has virtually used up the world's arable land. Planned extensive cultivation of single species has degraded good land and resulted in the loss of some genes to plant and animal systems. Increasing food production to meet population demand by intensifying agriculture, not expanding it into new areas, is, therefore, the option left to man, and this is dependent on environmentally stressful processes. The following strategies are being heavily employed, though not on any integrated world-wide basis. All lead to increased food production, but all demand an environmental price.

Selective breeding

Through experiments in genetics, new breeds have been created, more tolerant of cold and drought, more resistant to disease, higher yielding and richer in protein, even tolerating different photoperiods (length of daylight), so that more crops per year can be reaped from the same acreage. The breeding of short season corn varieties has extended the northern limit of this crop some five hundred miles (Brown 1970). High-yielding varieties of wheat and rice mature earlier, respond to fertilizer and are less sensitive to daylength. Thus, where water supplies are adequate, several crops can be reaped yearly. At the International Rice Research Institute in the Philippines, three crops of rice are reaped yearly — regularly. In India, winter wheat is alternated with summer rice. Thus, more of the sun's energy is converted into food, and the threat of famine does not loom as large. But the use of chemical fertilizers is heavy; neither can the fact be escaped that the large scale cultivation of single species and varieties lends itself to the spread of disease. Each plant is like its forbearer genetically; each stand is a clone wherein there is no variation, save that provided by the environment. The result is, that should disease strike, there is no pool of genetic variation on which natural selection can draw for resistant strains and the whole population is likely to go.

Fertilizing

The use of chemical fertilizers can increase the productivity of soils enormously — even to three and four times the normal in areas like Japan and the Netherlands where they are extensively used. Indeed, their use has increased greatly on a world scale since the end of World War II, as shown in Figure 21 below. The run-off from the fields into rivers and lakes has accelerated the process of eutrophication — because of the increased nutrients, algal growth intensifies. This massive growth leads to the depletion of the supply of oxygen in the water, and therefore, fish die. In the long run, if the process is not reversed, the body of water becomes a swamp. There is also the problem of maintaining potable water supplies for human use.

Pest control

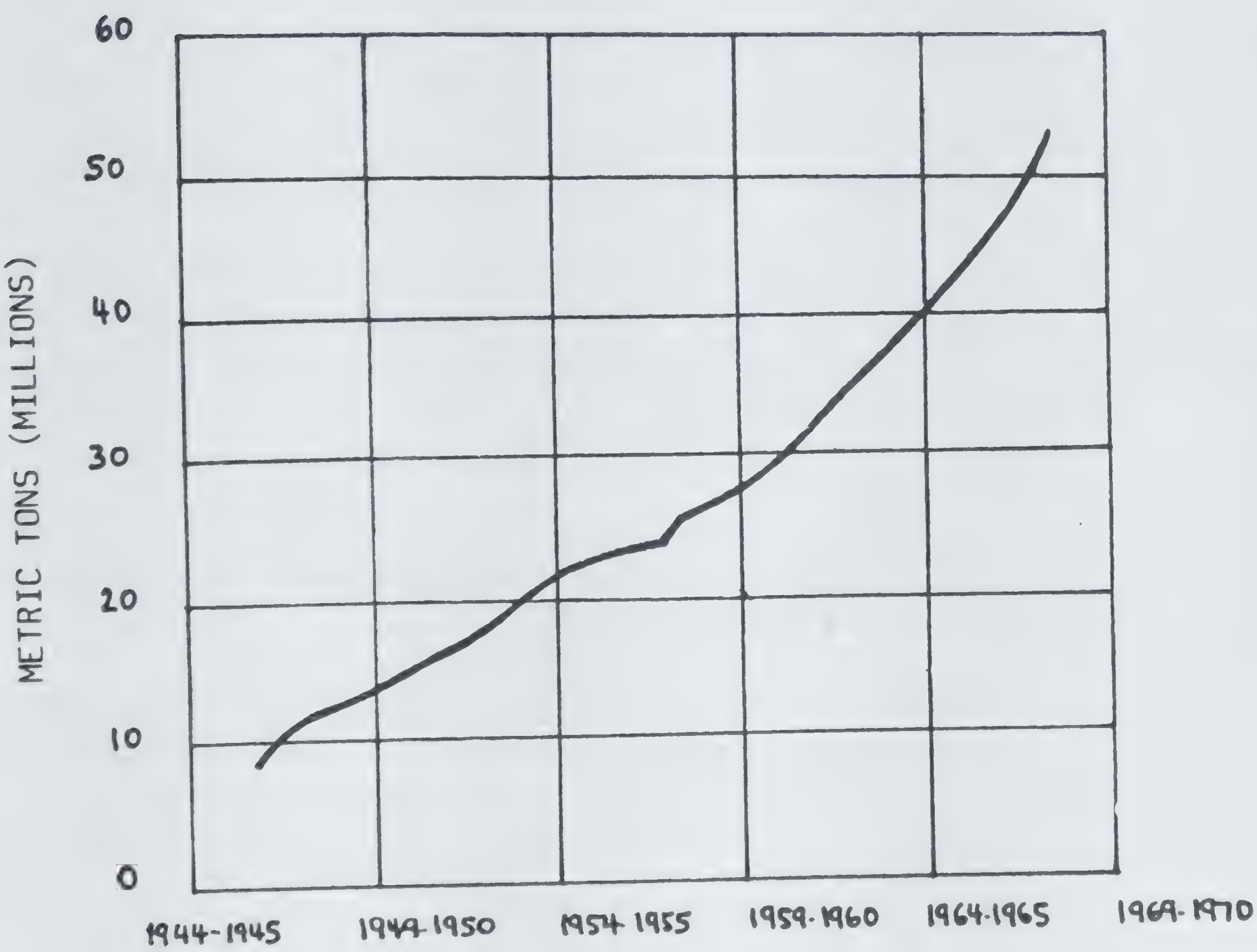
Some crop pests have been artificially controlled by cultural techniques, e.g. timing of sowing dates, harvesting and rotating of crops. Disease-resistant varieties have been developed. Irradiation of male insects so that the reproductive cycle is incomplete has had some success, e.g. in the United States and adjoining areas of Mexico with screwworm flies. Pest predators have been introduced.

By far the greatest control measure used, however, has been pesticides. An estimated 1000 such chemicals exist, of which a quarter of a million tons are sold annually (MAB 24 p.12). Several deleterious effects have ensued from their use: —

a. many are broad-spectrum chemicals, therefore non-target species are killed. This has resulted in the emergence of some new pests, where natural predators which would normally have kept them in check, have been killed;
b. pests develop resistant strains, altering the genetic pool;

c. some pesticides are persistent. Concentrations tend also to increase through food chains. A carnivore, feeding on herbivores which have consumed large quantities of vegetation sprayed, for example, with DDT, will be likely to have great concentrations of the chemical in its tissues. Indeed, the use of this particular chemical has now been banned by law in many countries — but much damage has already been done;
d. as with chemical fertilizers, the possibility of contamination of water exists, with its consequences for human and other populations in view of the toxicity of the materials.

Figure 21: Increase in Fertilizer Consumption Since the End of World War II*



*Source: Brown (1970)

The kepone story provides but one example of the far reaching consequences of this type of contamination. Kepone was developed for combatting the banana borer which, as the name suggests, afflicts banana plants. Extensively manufactured at Hopewell on the James River, Virginia, U.S.A., it was exported to tropical banana producing countries. In the 1970s after some years of wide usage, it began to be realized that the pesticide was deadly poisonous to living things, no matter how carefully it was used. It was bioaccumulative, recycling through body systems — blood, liver, gut — and eventually the nervous system, causing paralysis. No treatment is known, and even dead bodies are dangerous since no agent has been found which can break down or degrade the chemical. The only known way — passing it through a quartz tube at 1000 degrees

Celsius — is obviously not a practical method. When in 1975 it became obvious that employees of the factory and their families had been irreversibly damaged, the manufacturers were heavily fined (US$ 13 million), and the factory levelled — but the contamination continues. Seepage from sewage dumped into a lagoon, and rain water draining from the site have poisoned the river and Chesapeake bay. Although millions of dollars have been spent by the U.S. government in the attempt, it is doubtful whether the river can be truly cleaned.

Irrigation

Irrigation has played an enormous part in increasing food production by allowing the profitable cultivation of many areas which would otherwise not be usable. Rice, a staple crop, requires submergence. Large river systems, as well as smaller systems based on wells, are employed.

Whichever is used, there is an intervention in the water cycle. One effect of this is the raising of the water table. Waterlogging of plant roots may occur, and the surface soil may become increasingly salty as water rises through it and evaporates at the surface. This may lead eventually to its abandonment as agricultural land. The process can, however, be reversed, as occurred in the West Pakistan experience with the Indus: here the accumulated ground water was tapped to yield several tube wells. This lowered the water table, and, using water from the wells for further irrigation washed the salts down, relieving the salinity effects.

Another important side effect of perennial irrigation, especially in Africa and Asia, has been the increased incidence of Schistosomiasis. The disease is produced by the parasitic larva of a blood fluke harboured by snails, both of which thrive in the irrigation systems. There they infect human workers, producing a debilitating disease.

Mechanization

The early use of draft animals for additional energy, and its subsequent replacement by mechanization in most regions of the world, has allowed for enormous increases in the production of food. There are, however, several undesirable spin-offs, including:

- the enormous expenditure of fossil fuel to run tractors and other engines;
- the particulate and heat pollution of the air attendant on the use of the fuels;
- the reduction in the amount of organic manure consequent on the reduction in the number of draft animals, and the simultaneous increase in the use of chemical fertilizers;
- the removal of dead organic matter from the soil caused by some preparation practices. For example, mechanical reaping of sugar cane necessitates the prior burning of the field to remove much of the 'trash' or dried leaves from the plants. Normally, this would have been available for increasing the humus content of the soil. Many organisms are also killed by the intense heat.

Thus, the intensification of the production of crops tends to introduce instability into ecosystems.

Animals have also been reared for food. Foremost among these have been cattle, sheep and goats. Protein from these sources is, however, expensive: it requires about seven calories of carbohydrate to yield one calorie of beef. Chicken protein is cheaper, requiring about 3.5 calories of feed to produce one calorie of protein. Breeding experiments have been in the direction of developing strains selectively suited to different functions, for example, cattle which yield abundant quantities of milk, or beef: chickens which produce prodigious numbers of eggs, or mature for the table in a few weeks. From the point of view of satisfying world demands for food, however, consuming the energy that is put into the production of animal protein at a lower level in the food chain, would be more effective. The limitations, in spite of the recognized necessity for some special amino acids mostly of animal origin in human diet, are largely cultural. In other words, but for the

preferred eating habits of some members of Homo sapiens, others might be adequately fed who now are not.

Fish protein, mostly from the sea, is another well-used source of protein. Heavier exploitation of this source has been suggested in view of increasing demand, but overfishing could result in the eventual destruction of the population, since immature forms would undoubtedly be killed before they would have had a chance to reproduce.

To 'feed', however, is not to keep 'bellies full'. The situation now exists where the threat of large scale famine has largely been removed, because better transportation has made possible the export of huge quantities of food, mostly grain, from the more developed contries to areas in need. In spite of this, it is estimated that a half of the world's population is still malnourished — some estimates of this figure are higher, up to two thirds. Not unexpectedly, most of this population is in the poorer countries.

The greatest problem of malnutrition is the provision of adequate protein, although the importance of total calorie intake is recognized. Since, however, protein forms the basic matrix of protoplasm, adequate supplies are as crucial for mental, as well as physical development, particularly during the early years. Perhaps the greatest misfortune of the developing countries, is that their greatest asset, their human resources, can only function at a fraction of its potential because they are malnourished.

At the present time distribution of food is a major problem. Enough food can be produced to feed the present population of earth, but there are problems in getting the food from the food producing regions that have surpluses to the regions where there is not enough food for many.

By the end of the century, it is estimated that sixty million tons of high quality protein would be needed to supply the expected over six billion people of the world adequately. In other words, over the last three decades of the century, there will need to be a greater increase in food supply on a world basis, than there has been in the 10 000 years since organized agriculture began.

The challenge will be to design ways of accomplishing this necessary increase without detriment to the environment, and to educate farmers on the need for using such ways.

Meeting the need for water

The biological impotance of water as the most essential metabolic requirement of all living things has already been pinpointed. Very literally, no water means no life. There are additionally, the requirements for domestic purposes, agriculture, manufacture and industry, transportation and recreation.

Against these demands must be placed the quantities available. It also needs to be constantly borne in mind, that except for some transportation and recreational uses, the requirement is for *fresh* water, which forms only a very small portion of world supplies, three-quarters of which is locked in ice caps and glaciers (see page 42). Thus the very finite nature of this resource is immediately apparent. Any attempt to provide for man's needs means not an increase in the **total** amount of water, but rather an interruption of the cycle through which this amount is kept constant in nature on a global basis. These attempts have centred around strategies for storage of surface water against times of scarcity including the damming and/or redirecting the course of streams and rivers, tapping underground supplies through wells, cloud seeding to promote local rainfall, desalination of sea water and recycling used water. All of these strategies, while beneficial at one level, generate ecological, economic or social costs.

Storage of surface water

Man has for centuries built tanks to store rain water for domestic use and for irrigation during dry periods. At this scale of use, environmental costs seem low and 'containable'.

As populations are concentrated and agricultural schemes and industrial processes increase in size and sophistication, they demand greater and more dependable supplies. Therefore, the natural flow of rivers has been dammed to produce huge artificial lakes. Additionally, flood waters may be contained. The benefits accruing to man from an assured supply throughout the year for those demands are obvious. There may also be secondary benefits in the form of fisheries for food, or recreational assets. On the other hand, some good arable land may be lost in the 'drowning' of valley farming units, or in the cutback of a river delta. Flooding with its attendant depositing of silt and new nutrients may be a necessary condition for maintaining the fertility of these deltas. Downstream from a dam there are concerns for heat and/or chemical pollution of the stream, and the levels of water needed to support aquatic life. Whole human settlements may be lost, resulting in social and psychological problems of relocation, and future of cultural loss.

In all cases, whole ecosystems will have been upset, and the range and scale of consequences which might result are often uncertain and unforeseeable. The case of the Aswan High Dam on the Nile is an oft-cited example of this. The construction of the dam has removed the periodic enrichment of the delta which was caused by the silt brought down by the river. This has, in turn, reduced fish productivity in the Mediterranean because of the stoppage of the flow of nutrients into that sea. At the same time, the chemical fertilizers which have replaced the natural supply of nutrients have killed fish in delta lakes directly and indirectly by increasing the rate of eutrophication (Simmons 1977).

Where the considerations span more than one river system, the consequences could be awesome. The U.S.S.R., for example, has considered transferring enormous quantitities of water from one of its great Asiatic rivers, the Ob, which drains into the Arctic, from the normal course which floods in the spring, to the desertlike Kazakstan region. This would release vast acreages of fertile farmland for agriculture. There could, however, be dire consequences for world climate, as the atmospheric circulation of water vapour would be affected.

Tapping underground supplies

This is done by means of wells. Problems associated with their use concern finding out the quantity and quality of the supply. Several wells in one area could draw more heavily on the underground supply than it is being replenished. Where this occurs in coastal areas, there could be an influx of saline waters which might have consequences for all living things in the area, including man's health because of the increased level of sodium ions in the water he consumes. Chemicals from agricultural and industrial, as well as domestic wastes — garbage and sewage, may also be polluting the supply.

Cloud seeding

One important problem here is in human interrelations. Encouraging rainfall is of local benefit, but its generation in one area is likely to lessen the fall in other areas downwind, a situation which would be resented in the latter communities. Additionally, the changes which might result in the type of living organisms which can exist in the new environment arising out of the widespread practice of this strategy cannot be foreseen. Such practice would, therefore, be unwise.

Desalination
The desalination of sea water has been practised for a long time in some countries, especially where there are no natural bodies of fresh water e.g. in Aruba, Curacao, Barbados. Maintaining the huge physical plants necessary, as well as the salt extraction process itself, are costly in terms of both energy and money. On the other hand, man, in these situations, has little alternative. If new and cheap sources of energy can be developed, an important application may be for desalination.

Recycling
This has been common practice for some time in many areas. While this is a desirable direction of approach (closed cycle), the care that needs to be taken to monitor the purity of the supply is of extreme importance. Whole cities could be decimated by disease if controls are relaxed.

Meeting the need for minerals and energy

The needs for minerals and energy are considered together because the problems are so intimately linked. Mining operations attendant on providing both mineral and fuel supplies create a host of environmental problems.

Dust from ores and coal is released into the air. Extraction of minerals from their ores demands a heavy energy input: much heat is released into the atmosphere and waste materials from the extraction processes contaminates ground water. Transportation of fuel supplies carries the risk of explosion and oil spills at sea, with their consequences for marine life — and these are not rare occurrences. Mining operations may leave large open pits, and mined-out underground areas such as are produced in coal mining, may cause the 'fall' of areas above them. Removing peat deposits will also result in a lowering of ground level, and change the whole character of the area which will revert to swamp. Unsightly slag heaps, open pits, abandoned equipment, etc. detract from the appearance of the landscape. Topsoil and vegetation may be irrevocably destroyed, leaving an area very prone to the action of erosive agents like wind and water.

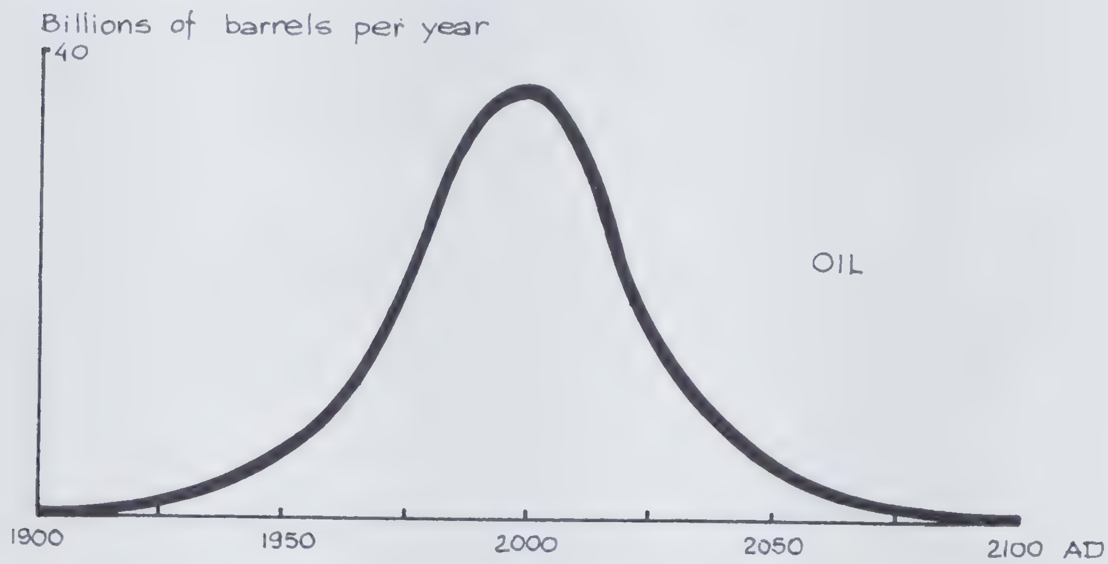
These ecological problems are continually being intensified by the growing scarcity of accessible sources of minerals and fossil fuels. Figure 24 below shows that oil resources may be virtually exhausted by the turn of the century, though that of coal will last a few centuries longer. Table 3 gives an indication of the quantities of known reserves of minerals in 1970, the world primary production in 1973, average growth in production (in 1970) and the estimated length of time various elements will last at current rates of usage. It can readily be seen that by the year 2000 reserves of aluminium and copper will have been exhausted, and those of iron may last only a further eighty years.

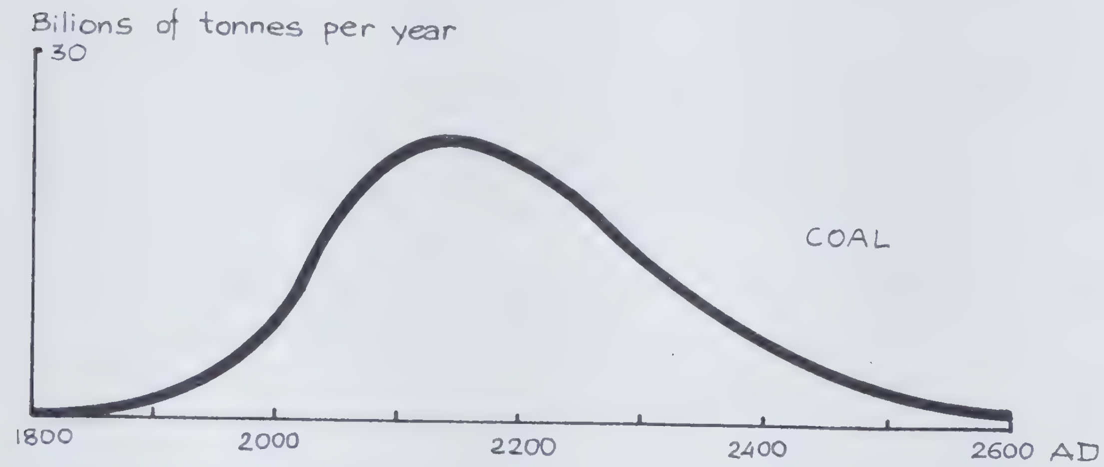
One response to the problem in industrialized nations is to design new technologies for extracting supplies from hitherto unused and poorer sources. For example, the large oil shale reserves of North and South America are being exploited — but new and immense problems for waste disposal and environmental control are thereby being created. It is estimated that an oil shale plant designed to produce 50 000 barrels of oil per day would have a daily waste of 100 000 tons of shale.[1] Ecological costs thus increase as the difficulty in recovering the ore fuel becomes greater.

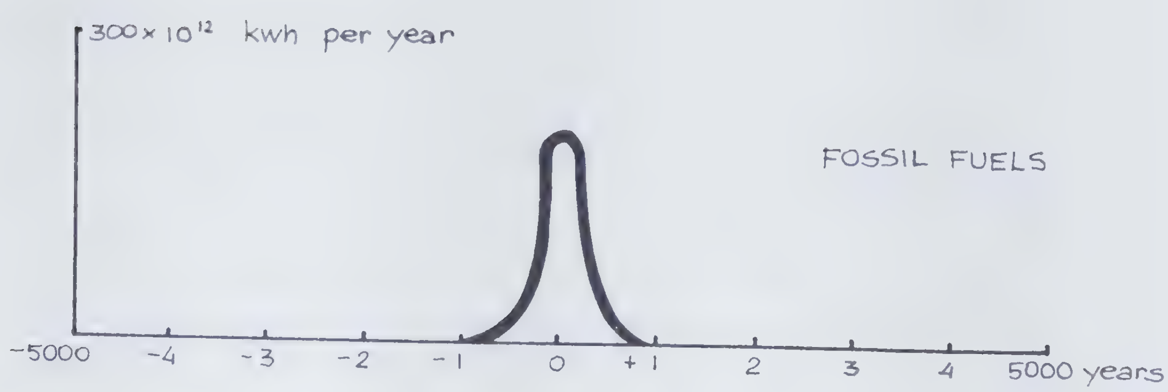
The sea has also been considered as an additional source of minerals and fuels. This implies recovery either from sea water or sediments on the sea bed or beneath the sea floor. The technology

[1] Robinson, Edward (1981) p. 3.

Figure 22: Probable Production Cycles for Oil, Coal and Oil, and Coal Combined







*Source: Robinson, Edward. **op. cit.** Figure 3.

TABLE 3: Selected mineral elements, known reserves and consumption for 1969, growth rate, and duration if rate of use continues*

Mineral element	Known world reserves (millions)		World primary production 1973 (million)	U.S. consumption as percent of world production 1973	Average growth rate (%)	Exponential index (E. I.) (years)	E.I. if world reserves were 10 times as large (years)
FERROUS METALS							
Cobalt	4,800.0		56.51	33	1.5	55	175
Iron Ore	250,329	lg tons	850.72	17	1.8	102	222
Molybdenum	10,827.0	lbs	181.15	31	4.5	29	74
Nickel	73.5	sh tons	0.73	27	3.4	44	105
Tungsten	2,824.0	lbs	85.32	21	2.5	24	89
Vanadium	10.1	sh tons	0.021	29	4.4	70	122
NONFERROUS METALS							
Aluminium	1,168.0	sh tons	13.36	42	6.4	29	63
Cadmium	0.71	sh tons	0.018	33	2.7	27	91
Copper	307.9	sh tons	7.84	22	4.6	22	64
Lead	95.3	sh tons	3.80	18	2.4	20	81
Mercury	3.2	flasks	0.28	19	2.6	10	53
Platinum gp.	424.0	tr oz	5.17	35	3.8	37	91
Silver	5,500.0	tr oz	305.92	64	2.7	15	65
Tin	4.3	lg tons	0.23	26	1.1	17	102
Zinc	123.7	sh tons	5.79	26	2.9	17	68

*SOURCE: Robinson, Edward. *op. cit.* Table 2.

for handling the great volumes of water that extraction of minerals in solution would entail is not currently available. It has been estimated that 9 000 billion gallons (34 065 $\times$ 10^9 litres) of sea water would need to be processed to yield 400 tons (406.4 mt) of zinc. Presently, only common salt, magnesium and bromine are extracted in commercial quantities, and their supply seems ensured.

Sediments on continental shelves may contain workable quantities of gold, tin and diamonds, but their extraction would create great imbalance in the sea floor. Off shore deposits of oil and natural gas are already being exploited, and constitute the major share of the materials extracted from the sea. Grave consideration of ecological disturbance to the sea must be weighed against any proposals for extraction of materials from it. The ocean remains one of the major stabilizing and protective ecosystems of the world. Perhaps because the interactions among its organisms are less obvious to man, there is good reason to be even more careful in causing changes in its ecology.

Much attention has been given to the possibility of expanding nuclear energy sources. This nuclear energy would then be available in abundance, but its use carries with it awful and awesome responsibilities. The radioactive nature both of the raw materials and of the waste products, poses a serious problem, since there is no foolproof way of protecting living organisms from the effects of exposure to radio-active material. The damage to the genetic pool, and the nightmare that this might mean for mankind, have been dimly conveyed to us in the wake of Hiroschima and Nagasaki. The physical damage to the cities as a result of the 1945 atomic bomb explosion was so great that the communities disintegrated. Services broke down as most of those who should have provided them were dead. Physical handicaps abound in the present human populations. Susceptibility to disease and fatigue threatens employment. Fear of genetic damage prevents marriage even now, more than thirty years after.

In spite of the recognized dangers from radiation, there were, up to mid-1974, some 125 commercial power reactors of different designs commissioned or in operation in several parts of the world. The largest, of a rating of 1050 MWs is to be found in the United States of America.[1]

Problems of trade and international relationships have also been generated by patterns of supply and demand with respect to minerals and energy. The distribution of resources bears no relationship to the political boundaries of the countries wanting to use them, nor to the relative quantities in which these are used by different nations. (It is well recognized that the industrialized nations use the 'lion's share' of these resources).

Two of the problems which ensue are, firstly the demanding of higher prices for scarce commodities which affect poorer countries in particular. Secondly, many poor countries with ore or mineral deposits of their own are at a disadvantage both economically and ecologically, because they do not have the financial and technological inputs to develop their own resources. Often they do not insist on proper environmental safeguards and a fair return from those who do exploit these resources. The development of bauxite mining in Guyana and Jamaica are cases in point.

Bauxite mining was started in Guyana in 1917, but until recently developed slowly. In Jamaica, the surge in demand for aluminium during World War II precipitated the testing of known deposits of bauxite ore which were found to be extensive and capable of easy recovery since they were near the land surface, although not as high grade as Guyanese ore. The workings in both countries were, however, owned by American and Canadian companies.

Guyana has large deposits both of high grade bauxite containing 60% alumina in the lowlands where it is easily accessible, as well as of lower grade ore in the south and in the Pakaraima mountains. In order to reach the deposits, however, the overlaying forest has to be chopped or burned down, and 100 feet of overburden of white sand must be washed away. The ore is then

[1] Satamanthan, S. 'Energy Alternatives' in W. I. Science & Technology, Vol. 1, No. 1.

blasted away. This means that the process destroys forests, removes topsoil and leaves in its wake large areas of virtual desert. Up to 1971, the giant Canadian company which owned the deposits exported the ore itself (although Guyana has the hydro-electric potential for smelting aluminium) because it already had its own plants and aluminium factories in other parts of the world. With bauxite then valued at \$18 per ton, alumina at \$150 and aluminium at \$1000 per ton, it was obvious that Guyana was paying a heavy environmental price without even the compensation of receiving an adequate share of the financial benefits. In 1971 the Guyanese government took over the ownership of bauxite and alumina production in an attempt to redress the financial situation. Unless, however, the country develops the expertise to process alumina there, it will continue to relegate to the industrial countries the greater share of the financial benefits from this resource. What, however, can it do about the environmental costs?

In Jamaica, the works are still partially foreign owned. There is the inflow of income from royalties and income tax, but the island's energy position allows it only to accommodate the initial stages of aluminium production — that is, unlike Guyana, it must export the ore either in the dried form, or converted to alumina. The later stages, which generate more jobs and income take place in the United States of America, at Kitimat in British Columbia, Canada, in Scandinavia, etc. But, like Guyana, Jamaica must bear the consequences of the physical and social environmental impact of the mining industry. Foreign owned companies control one tenth of the land surface of the island, and the higher wages paid to the relatively few employees (about 10 000), cannot be matched by local companies. It is true that mining companies are required to reclaim mined out areas, so that most of this has been converted into usable pasture lands, but the dust and chemical pollution problems remain.

Human settlements

Overall, the problems discussed appear to be associated with one or more of certain categories of effects, namely, pollution, depletion, land disturbance, heredity, disease — and their consequences for human social, psychological, economic and cultural welfare. The severity of all problems is exacerbated by the continuing increase in world population.

Man is one member of the animal kingdom that has had a sharp upward trend in numbers. The behavioural and physiological responses of other species collectively ensure that over time, fluctuations in populations vary around a certain mean, in keeping with the capacity of the environment to maintain them (see page 46). These are, however, instinctive responses, but in human beings, population regulation can be subject to conscious and deliberate behaviour.

Estimates say that it took more than two million years for the human population to reach the one billion mark, but that the fourth billion took only fifteen years (1960—1975), and by the year 2000, the population is expected to be above six billion. (Billion here = 1000 million). Increasingly efficient medical care, the virtual eradication of scourges like small pox and malaria, have meant not only decreasing death rates but longer life expectancy. The population has grown correspondingly.

This continuing increase must be seen in conjunction with the changing patterns in human settlements, with the emphasis on urbanization and dependence on industrial rather than on agriculturally-based economies. That problem, associated with the increase in numbers, is compounded by population distribution. In 1960, it was estimated that about 20 per cent of the world's population were city dwellers; by the end of the century, the figure is likely to be 60 per cent.

Urban and industrial areas 'import' materials into their systems which presently have little to offer to their own ecological maintenance. Instead, they consume a disproportionate quantity

of available resources like food, water, energy and oxygen. They concentrate waste, and its disposal is an unresolved problem, intensified by the increasing contribution of containers made from synthetic materials that are not biodegradable. These densely populated areas expose more people to local environmental hazards, such as fires, floods, contagious diseases, as in the Nagasaki example just cited.

Urban centres are also characterized by the social problems of overcrowding, hunger, malnutrition, inadequate health and housing facilities, unemployment, crime, and loneliness. Here the uneven distribution of wealth is starkly depicted in ownership and style of housing, clothing, cars, and household appliances.

One manifestation of these problems is the 'shanty towns' which develop adjacent to a vast number of urban centres. These are slum areas arising out of the concentration of the poor on marginal and often unstable lands, which are cheap. Although the degree to which this is true varies with the economic level of the country, their physical siting often precludes the proper provision of basic amenities — piped water, garbage and sewage disposal arrangements, and electricity. In South-east and Central Asia, for example, it has been estimated that some two-thirds of city dwellers are without piped water. Inhabitants thus resort to the use of untreated water. Refuse from dwellings and from open market places forms a breeding ground for disease organisms, especially in tropical and sub-tropical countries where the warmth contributes to their proliferation. The easy spread of contagious diseases is, therefore, a health hazard. Water borne diseases like typhoid and dysentery are especially important because of the lack of water quality control.

Certain types of housing, as is illustrated, for example, in the style of some apartment buildings, do not provide their inhabitants with adequate facility to meet others in situations where contact can become meaningful. Though, for example, there may be ground space in the form of gardens and playgrounds, people living nearer the ground level are more likely to use these areas for informal contact than people living on higher floors. Whatever the reasons, there appears to exist a positive relationship between an increasing incidence of crime and delinquency and the spread of urbanization.

The city also carries with it the problem of noise — street noises from traffic, noise from aircraft, and noise from people. Noise may be upsetting physically and emotionally. High levels bring about chronic damage to hearing, and are related to the increased incidence of diseases that involve tension such as duodenal ulcers and hypertension.

Bakács (1970) has indicated that there is, in addition to man's physical and biological link with the environment, also a 'psychic climate', rich in environmental stimuli, the incidence of which is increased in urban areas. Man is able to 'tune out' some of these stimuli, but the ability to do this is limited. Imbalance in this environment may result in mental illness.

Man must apply his considerable ingenuity to the solution of the wide range of environmental problems in ways which will also promote the well-being of the whole complex of living organisms.

CHAPTER 4

Dealing with problems

Problems are sociological, technological, economic, ecological — all aspects have to be considered together. They demand solutions and solutions require not only intense study and understanding of causes, consequences and possibilities, but the will and the authority to weigh evidence, make decisions and act on them. Basically, there must be a change of **attitude** by man. As was posed in proposing a philosophy for environmental education, the latter must lead man toward a new ethic, where he seeks to be in harmony with nature. Always in his consciousness must be the awareness of the finite nature of all the earth's resources. Further, he must acknowledge at a personal as well as at the wider community, national and international level, his own responsibility for protecting and improving the environment of which he is an important part, not an onlooker. He must be educated to a pitch of awareness where he is attuned to recognize the signs and symptoms which indicate a breakdown in ecosystem equilibrium and incipient environmental problems.

He must be willing to study and seek to understand the systems of nature in as far as he is capable, so that he can apply the principles to managing the ecosystems he creates. Only in this way can we hope for a desirable level of quality of life for himself in the present, and for future generations.

Once the stance of working in conjunction with nature has been accepted, practicality directs that there be some method in the approach to finding solutions to environmental problems.

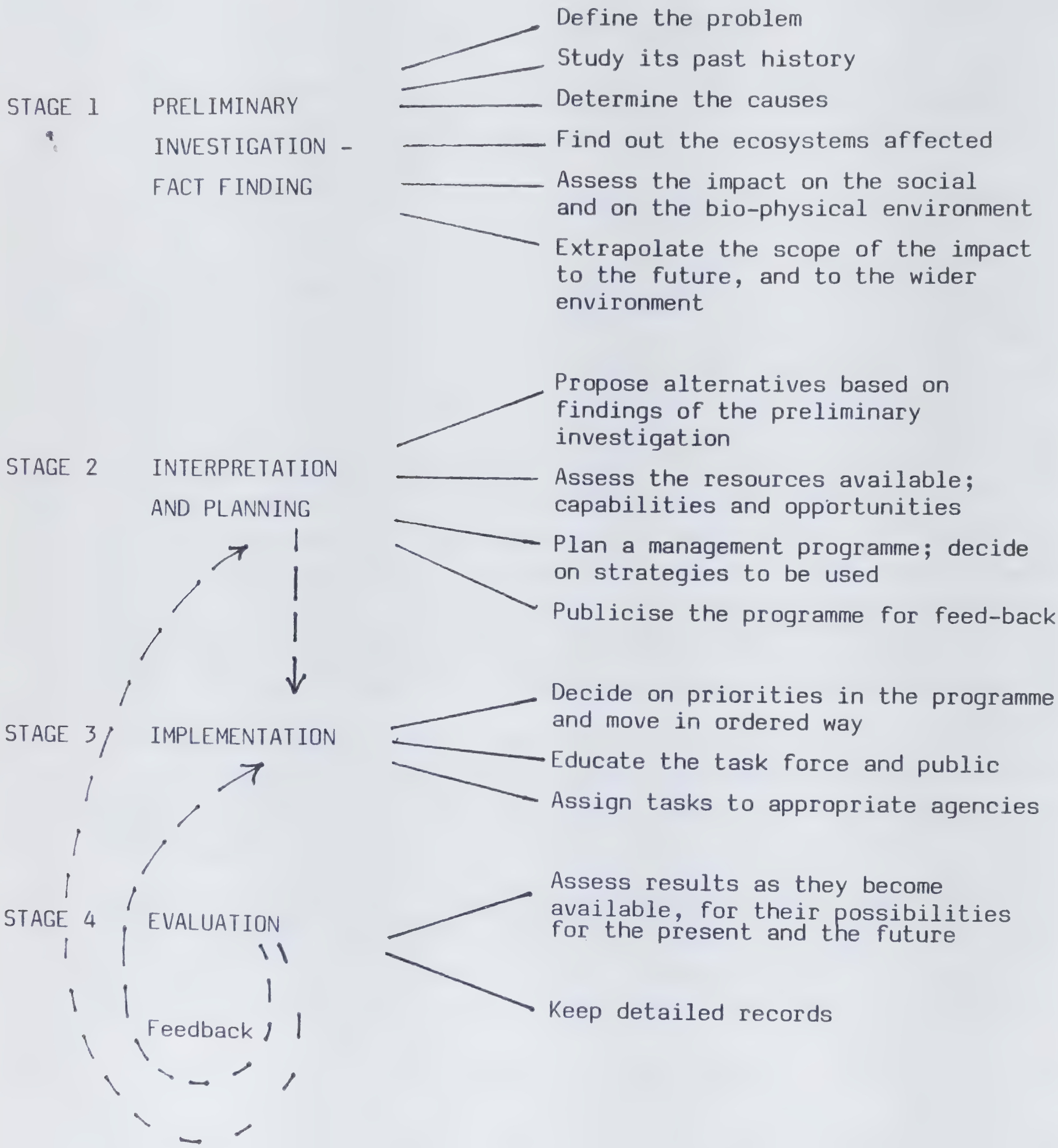
A generalized model of such an approach is presented in Figure 23. It might be used at any level of problem solving — local, national or international. It cannot be used until those desiring to use it have themselves demonstrated a commitment to the preservation/improvement of the environment and have clarified their priorities guided by this commitment.

The solutions to some of the problems generalized by natural disasters and by food and energy requirements are analysed on the basis of the model to illustrate how it might be applied.

Naturally-occurring problems

To date, no way of avoiding these exists, but their impact can be considerably reduced if international and national authorities, local civic authorities and people in general assume a stance of preparedness. The public should be aware of the signs and symptoms which precede these occurrences and be attuned to warnings through the public media. Emergency mechanisms should be in place for alternative shelter, for evacuation, for medical aid. For example, the U.S. Weather Bureau Severe Local Storm Forecast Center at Kansas City issues tornado warnings, and many schools in the Mid-West have underground shelters. The National Hurricane Center at Miami,

Figure 23: Some Guiding Prrinciples for Finding Solutions to Environmental Problems



Florida sends aircraft daily over the Caribbean to observe and photograph cloud patterns which might indicate the birth of a hurricane. The scheme (p. 109) put out by the Office of Disaster Preparedness in Kingston, Jamaica, summarizes excellently the steps which might be taken to establish a position of preparedness.

The scheme provides an example of how the model might work in practice. The various phases of the scheme are classified according to the model in the table following.

Stage in Generalized Model	Phase in Scheme for dealing with natural disasters
1. Preliminary — investigation and fact finding	Hazard analysis Vulnerability analysis
2. Interpretation and planning	Preparedness
3. Implementation	Prediction and warning Mobilization Assessment Requirements and analysis Resource analysis Rescue and Evacuation Emergency assistance Rehabilitation
4. Evaluation	Reconstruction

There needs to be commitment as well as intensive training and practice in practical non-threatening situations if the scheme is to work. In this way, all involved will know their precise tasks, appreciate their importance, and act accordingly. This should help in alleviating panic, and swift action may help to lessen the more serious consequences of a disaster. For example, the implementation of a swift immunization programme may prevent the spread of a contagious disease.

Man-induced problems

Meeting the need for food

The central consideration is to increase world food supply and arrange for its equitable distribution to a rising population, while at the same time preserving and/or improving the environment and maintaining equilibrium in ecosystems. Three foci of attention present themselves in the light of past experience: the spread/intensification of agriculture; the utilization of unconventional sources of supply; and arrangements for distribution.

The model is now applied to each of these problem areas.

Table 4 Steps which might be taken to deal with natural disasters*

PHASE	RESPONSIBILITY	FUNCTIONS
HAZARD ANALYSIS	Scientific community historians local community physical planners.	Analysis of mechanics of natural and man-made disaster in terms of causes and effects and with reference to temporal and aereal probability of incidence.
VULNERABILITY ANALYSIS	Geographic communities scientific engineers physical planners.	Estimation of where and when natural hazards will strike populations.
PREPAREDNESS	Disaster planners civil defence scientific community legislators institutions/media local government officials	Mitigation programmes and organizational development, physical adjustments education and training, legislation, logistics and communications.
PREDICATION AND WARNING	Government officials scientific community disaster managers communications/media civil defense.	Monitor precursor events, recognize dangerous phenomena analyse potential threat, assess political consequences, alert public.
MOBILIZATION	Disaster managers media local government.	Alert responsible officials, activate funding mechanisms, requisition emergency resources, manage relief organization.
ASSESSMENT	Disaster managers scientific community military/civil defence Red Cross media.	Determine damage, determine causes/effects, determine resource deficits.
REQUIREMENTS AND ANALYSIS	Disaster managers media local government.	Estimate resources in community, estimate outstanding needs, identify unmet requirements, priorities requirements.
RESOURCE ANALYSIS	Disaster managers local government officials.	define requirements determine least-time/ least-cost source.
RESCUE AND EVACUATION	Civil authorities military & police Red Cross.	Ensure survivors safety.
EMERGENCY ASSISTANCE	Disaster managers civil authorities military/police, Red Cross, social workers private sector, other donors.	Monitor situation, analyze continuing needs, requisition and procure, transport and deliver, or provide life-sustenance, health, and comfort.

Table 4 Steps which might be taken to deal with natural disasters*

PHASE	RESPONSIBILITY	FUNCTIONS
REHABILITATION	Disaster managers, civil authorities, military, planners, financers.	Bring stricken community to state of normality.
RECONSTRUCTION	Development experts, disaster managers, scientific community, private sectors, planners, engineers, financiers.	Bring about higher quality of life/security against disasters.

*Source: Office of Disaster Preparedness (November 1980)

I The spread/intensification of agriculture

Stage 1 Preliminary fact-finding investigation

Very few areas remain where agriculture may be newly introduced. The strategies being presently used to promote intensification include the use of chemicals for fertilizers and for eradicating pests, irrigation and mechanization (see pages 83—86), selective breeding research and techniques. These practices, while accomplishing increased productivity have also caused, among others, the following which cause ecosystem imbalance:

— land use which precipitates ecosystem destruction, initiates soil erosion and changes the pattern of human settlements, causing social problems;
— pollution of air and water from the chemicals used to control weeds and pests (notably insects) and from fertilizers;
— the suppression of genetic diversity through monoculture practices and the implications for the spread of disease.

If continued, these could lead to diminished food supply as more land becomes unsuitable for supporting crops, as water becomes less available, and as eutrophication causes the loss of aquatic systems as a source of supply.

Stage 2 Interpretation and planning

Proposing alternative land use

One could inform the public of the ecosystem principles underlying widespread farm practices (e.g. 'slash and burn', monocropping, crop rotation, and mixed farming) with a view to encouraging a proper choice of practices. The 'slash and burn' method of agriculture, for example, traditionally practised in tropical forests for generations depends on a time factor which allows the plots which have been temporarily cleared to revert to the natural vegetation. This allows the plot to regenerate itself. When the plot is replanted too soon, the nutrient cycles are not re-established. The consequences are soil erosion, poor crop yield, and because of the latter, shifting human populations as the area becomes unable to support the population.

The simple measures of crop rotation, strip cropping and terracing, are also efficient in preventing soil erosinon. Crop rotation and the practice of mixed, instead on one-crop farming by not providing virtually unlimited host systems for disease organisms to breed, help to prevent the spread of both plant and animal diseases, and the consequent loss in production. The practices also allow for better cycling of nutrients in the soil; since different crops make different demands, excessive depletion of any one element is reduced. Crop rotation, strip cropping, terracing, and mixed farming, are therefore, useful practices which should be encouraged.

One could suggest certain new directions. The implementation of mixed farming in large scale agriculture, for example, would, in this case, require informed national and international policy, because many economies are built on the production of single crops, for example, the sugar cane, bananas, coconuts, wheat. The change would have implications for labour systems, world trade goals, and would require intensive preliminary study.

Planned land use built on sound ecological principles and a thorough knowledge of the geography, geology, economy and human population patterns of a particular area is another 'new' direction. The strategy involves the assessment, based on this knowledge, of the agricultural capacity of various land areas. Out of this assessment would arise a plan for their use- for grazing; for mixed agriculture; for one crop stands; for open land; or for residential and commercial areas. The strategy should be employed on a national scale, encompassing rural and urban areas. The planned urban area, though contributing less than a rural area, could then make an input into the production of food for its own population. Additionally, the oxygen liberated by photosynthesising green plants would lessen the debt of the city to other areas for this commodity. Perhaps the most difficult concept to gain public understanding of is the necessity to leave open land 'unused'. Odum (1971) suggests that at least a third of all land space should be so designated.

Proposing alternatives to pollution from fertilizer application and pest control

The more intensive rise of crop rotation and mixed farming would tend to promote a more 'closed cycle' of nutrients. Advantage should be taken of 'natural' means of replenishing supplies. For example, leguminous plants with their capacity for fixing atmospheric nitrogen, and therefore for increasing soil supply of this mineral should be widely cultivated in these systems. Species exist which are good fodder for domestic animals e.g. alfalfa, and excellent for man's consumption, e.g., peas and beans. The use of organic manure should be promoted: for example, the residue after extraction of sugar and rum from the juice of the sugar cane (dunder) is extensively used to recharge sugar cane fields.

Cultural pest control is the timing of sowing and harvesting dates, rotation of crops are methodologies which take into account the known life cycle of insect pests. Sowing and harvesting time may be so arranged as to be 'out of step' with the larval, destructive stage of the insect. Crop rotation, by depriving the pest of a continuously available source of food, helps to bring about its elimination.

Biological pest control can capitalise on known predator/prey relationships. Predators which will feed on the pest population are introduced or encouraged. The method carries a certain risk in that once the prey has been decimated, the predator may seek a replacement which might be a useful insect, or the predator may multiply until it, in turn, becomes a pest.

One example of this type of scheme which has been successful is the control of the prickly pear plant in Australia by use of a moth.

The utilization of unconventional sources of supply

Stage 1 Preliminary fact-finding investigation

This would involve the determination of such sources as are presently being used, and the ecological and/or cultural implications of using them. Yeast, for example, has been used. The plant has the advantage of quick turnover; weight is doubled every five hours or less — or thousands of times faster than animals. It can be cultivated under controlled conditions, and yields protein and vitamins comparable with those of animals. On aesthetic grounds, too, because yeasts are plants, they are not outlawed by religious or traditional taboos. The accompanying problem would be one of substrate provision. The traditional substrate is sugar; gas oil and paraffin have been successfully used. Both these sources are themselves now in short supply. The decisions to be made here include a compromise position in view of the capacity of yeast to supply protein.

Algal farms have also been used. Chlorella has been used in Japan. The technical expertise and space outlay for these constitute a limiting factor to their usefulness, although the alga is rich in protein and fat. On the other hand, the alga does away with the necessity for arable land. The 'space' could be anywhere.

Fish ponds have been successfully used for centuries in Europe and the East. The periodic draw down and drying out of the ponds simulates natures' periodic flooding of marsh systems, and maintains productivity.

It has also been suggested that since the Southern Hemisphere currently supplies only 2% of the world's fish, fishing grounds might be developed there.

Oyster culture practised in Japan yields 32,000 pounds of oyster from oyster farms; their strategy could be copied elsewhere.

Stage 2 Proposing alternatives

In any given situation, the ecological system must be examined to see whether or not any 'sources' being used elsewhere could profitably be instituted.

Untried sources may be explored on an experimental basis. For example, Odum (1971) raises the possibility of the greater use of detritus food chains. He argues that since the present strategy of selecting for growth based on high yield and edibility in food plants is largely supported by the use of chemical fertilizers and pesticides which cause pollution problems, the reverse tack should be employed. Un-palatable plants, or those which produce systemic insecticides might be selected. The yield from these might then be converted by microbial action and chemical enrichment into edible products. He points out that a similar process is already in place for domestic animals viz, the fermentation of low-grade fodder to provide silage. The ecological principles are sound; the problems would be largely educational and cultural.

Arrangements for distribution

Stage 1 Preliminary investigation

This would demand a thorough investigation on a world basis of present:

— production of food commodities;
— their capacity for increased production;
— areas of scarcity and their ability to improve their situation;

— the types of commodities which suit short and long distance transfer;
— the relative efficacy of preservation processes e.g. salting, canning, drying, refrigeration and their application to different types of food;
— present patterns of distribution: local marketing systems, trading links and agreements among countries; the economies of the system;
— disaster measures; procedures for alleviating famine.

Stage 2 Interpretation and planning

On a local scale, decisions would depend on the particular situation. General suggestions for improvement, however, might include:
— local but centralized distribution centres;
— improved road systems to promote transfer from productive to consuming centres e.g. city markets

On an international scale
— there would need to be agreements on the exchange and sale of products to facilitate more equitable distribution
— the infrastructure which presently acts in a disaster situation might be oriented to function in a more preventive way — to *prevent* famine and malnutrition
— educational inputs aimed at encouraging a change in feeding habits, to facilitate more dependence on the lower trophic levels of the food chain. Six tons of green would feed considerably more people than the single ton of beef it would produce

Continued research into new methods of preservation is necessary; these would widen the range of products which might be exchanged.

Stage 3 Implementation

The analysis of stages 1 and 2 has been presented in a very generalized way encompassing the three areas of attention identified. Implementation will depend not only on the specific problems to be addressed, but on priorities peculiar to a community. In considering such priorities, however, the fundamental concept of individuals functioning as international citizens must not be violated. Whatever decisions are made for the community/nation, must not be at the expense of the quality of life of any other community/nation.

Against this general premise, communities/nations will prioritize on the basis of
— soil and water resources
— labour resources
— technical expertise available
— existing dietary problems and health patterns

weighing at each step, potential against needs. The important role of research as an integral ongoing part of any strategy cannot be overemphasized.

Stage 4 Evaluation

As with the implementation process, this will be affected by the type of problem, and its context. Three important guidelines which should be observed, however, are
— detailed records of all programmes should be kept. All the information assembled in stages

1 to 3 of the process must be accurately recorded, as must any results arising out of the implementation;

— results must be examined as they are available, so that they can guide planning and implementation. Only in this way can they contribute to increased environmental awareness;

— **all** information should be available for the use of the rest of mankind. No environmental knowledge should be 'classified';

— research must be pursued on a continuous basis to identify as far as possible the effect of any strategies being pursued on ecosystems, with a view to diagnosing potential hazards, alleviating undesirable consequences already evident and ascertaining what is beneficial.

Meeting the need for energy

Energy plays a key role in all resource processes, and there is no substitute for it, only different ways of harnessing it. Its availability may well be regarded as the most important limiting factor dictating the quality of the environment and of man's life. Its provision contributes heavily to all types of environmental problems.

Two hundred years of a fossil fuel-based world economy have created a shortage of these fuels, whose replacement can only be thought of in terms of millions of years of geological time. The short-term strategy of using less easily-accessible sources of these fuels, for example, the oil shales, carries with it enormous problems of waste disposal. Nuclear processes introduce the awesome risk of radioactive contamination. The use of biomass for energy on an extensive scale has been considered by some countries, especially those of the developing world. Biomass includes all materials produced by bio-synthesis or the fixation of atmospheric carbon dioxide by plants. Therefore, the term can be applied to all such carbon containing material, whether from primary sources such as trees or crops, or from garbage or dung.

Currently, about half the world's population uses wood for cooking and heating, but the energy conversion is not efficient. This is better with charcoal, which has been prepared by baking the raw fuel in the absence of air. Other methods for using the energy from this source include fermentation. In Brazil, ethanol manufacture from sugar cane is used to supplement gasolene (up to 20%) as a fuel for vehicles. Methane can also be produced by the fermentation of waste in a biogas plant. The gas produced contains about 60% methane. In China, there are already (1977 data) nearly five million biogas plants producing the equivalent of 200,000 barrels daily of oil in gas. India also has some 81,000 plants, and it is hoped to raise this to 580,000 by 1983, producing 18,000 barrels a day oil equivalent of gas, and 12 million tonnes of fertilizer per year.

The use of biomass carries both advantages and disadvantages. While perhaps not finite in the same sense as the fossil fuels, since, if done on a commercial scale, the plant material cultivated exclusively for energy supplies can be renewed annually, there are the problems of availability of land since there would be competition with agriculture with regard to space and fertilizer supply. Its cultivation therefore presents the same sort of hazards as organized agriculture. Since also supply and demand would not be matched geographically, some means of processing the raw material would have to be worked out; wet biomass is difficult to transport. The product would, perhaps, therefore be better utilized on a local scale. Very great care would also need to be taken, to ensure that replanting techniques do not encourage soil erosion and extreme ecosystem upset. In order to be consonant with the premise of working in tune with the environment, it appears, therefore, that the best options open to man are:

a) to utilize to their fullest capacities those energy sources — tidal, wind, geothermal and hydropower — which do not invite environmental problems, and

b) to devise ways of using solar radiation directly. Green plants fix only about one per cent of this energy reaching the earth; most of it is wasted as heat.

Neither of these will make energy available on a grand world scale as with either fossil or nuclear sources. But perhaps each country or group of countries may take decisions on what its strategy might be, as long as recognition is given to maintaining the integrity of the environment, both in their own situation, and as their actions might affect others.

The use of solar energy is not new. Lavoisier invented the solar furnace in 1772, and in the 1870's solar energy was used by the French to operate steam engines and to make ice. The advent of cheap fossil fuels caused solar technology to be largely abandoned. Now, it is being revived. Two examples of its effective use follow.

At Dire on the Niger River, 200 kilometres south of Timbuktu, the French have installed a solar plant of 80 kilowatt capacity. It will supply the water and electricity needs of the 7,000 inhabitants of the village. The plant is of the thermodynamic type; the sun heats water which will run an engine and a pump to 'draw water' for drinking or irrigation or an alternator to produce electricity. At San, the hospital which serves 200,000 inhabitants, has two generators, one of 8,900 watts to supply its electricity, the other to feed a pump which draws 26,000 litres of water per day. These generators are run from photovoltaic cells, which transfer solar energy directly into electricity.

Dellimore (1979) has suggested for the Caribbean a working model for providing present and future energy needs which makes use of these two environmentally profitable options. His proposals are outlined below and they fit into the generalized model illustrated.

Providing for energy needs in the Caribbean (after Dellimore, 1979)

Stage 1 Preliminary investigation and fact-finding

— Examination reveals that for the Caribbean —
  a) there is presently almost total dependence on fossil fuels with some contribution from hydropower and the burning of bagasse in the sugar industry
  b) the region is moving into an age in which electricity will be an important form of energy. Electricity is costly as a source of heat and work, but offers superior process and quality control and scope for 'new approaches' to production, consumption and organization.
  c) industrial activity tends to be restricted either to primary production and crude processing or to assembly-type operations. These terminal activities are not energy intensive, but contribute little in terms of value. For the future, more core operations are needed to provide more jobs
  d) provision for energy needs must take account both of an 'industrial revolution' and of 'socio-cultural evolution' in the area. The zero-growth patterns aceptable as strategies for the advanced countries are not acceptable here

— The ecological impact of heavy dependence on fossil fuel is as elsewhere basically (see pages 92—97) injurious.

— All alternative energy sources except tidal energy exist in the Caribbean at exploitable levels. They include solar, wind, water, and biomass sources. The energy is free, but the capital required for obtaining them is high, and ecological costs are sometimes also high.

Stage 2 Interpretation and planning

Dellimore proposes the use of alternative energy sources through a gradual progression which introduces first a mix of energy sources, then is finally resolved in the long term in entire dependence on solar energy.

Dellimore proposes three phases to the planning strategy. The principal goal should be a reduction in the dependence on fossil fuels by the 1990's while allowing for the increased energy consumption attendant on creating employment and lifting the standard of living in the area.

Phase 1

a) Initially, existing projects and plans will cause increased consumption of fossil fuels. But
   — major conservation measures to prevent waste,
   — use of waste heat from oil generated electricity plants (some 70% of the chemical energy released in these plants is discarded as heat),
   — exploitation of the hydropower potential, and
   — intensive development of biogas, windmill and geothermal energy sources

are measures to be undertaken. New projects should be based on the new goals for energy.

b) Costs for this phase would be approximately U.S.$ 4–5 billion. Against this must be considered the fact that the current energy bill for the Caricom countries is about U.S.$ 1 billion per year.

Phase 2

a) Two main considerations for this phase which might last centuries are the attainment of self-sufficiency in energy for the region and ending inflation in energy prices.
b) The 'mix' of energy sources begun in Phase 1 will intensify, the aim being a reduction in the use of fossil fuels and an increase in that of solar radiation, with other sources like wind and water forming the transition strategies.

Phase 3

The goal of this phase is the almost total use of solar radiation for all major industrial, commercial and residential energy needs.

This goal, Dellimore asserts, is one which is common to all societies: material things will be more durable and more cognizance will be given to moral and social values, including, one surmises, the enhancement of the environment.

Stage 3 Implementation

1. Recognise priorities governing programme design.

The goal must be adequate power levels at low capital cost. Therefore, the ease with which alternative energy sources provide adequate power outputs should be the principal criterion for the allocation of scarce funds: against this criterion, environmental impact must be weighed. Implied is the flexibility to change emphasis in the development of sources as new technologies present ways **either** of raising the power outputs easily obtainable from low power density flows, for example, solar radiation, **or** lower the power demands.

2. *Strategies to aid implementation*

For Phase I

i) New approaches to organization of production and planning based on regional economic integration rather than on local self sufficiency (because of polarization in distribution of oil, hydro-electric and mineral resources in area)

ii) Development of new styles of leadership — informed leaders who can 'work within a policy framework and share political control within a collective leadership' (Dellimore op. cit. p. 17) are needed

iii) New approaches to gathering and storing information
   — on physical data
   — on available production technologies which might facilitate change to alternative energy sources
   — on 'consumption' of energy by industrial, commercial and private users

iv) Research and development, and education with emphasis on alternative energy, and especially on means of concentrating and storing it for industrial use

Beyond Phase I

Development of systems for concentrating and storing the energy generated

3. Outline at each phase a Caribbean Alternative Energy Policy to give legal status to the plan proposed.
4. Follow stages outlined, with due recognition to any necessary change in emphasis as noted in (1).

Stage 4 Evaluation

The proposals for research, collection of data, recognition of new technologies and their import for influencing emphasis in the plan are all evaluative.

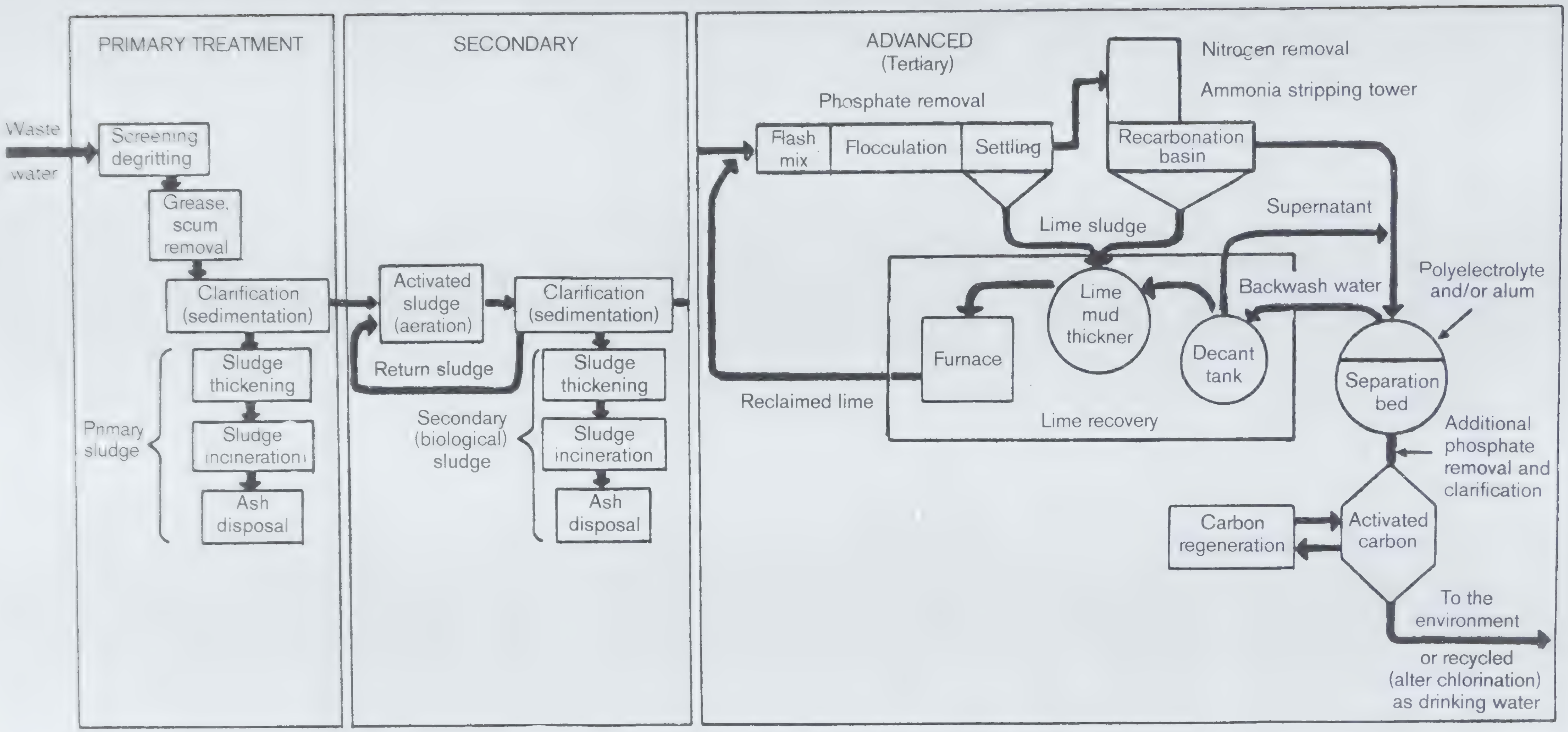
Meeting the need for minerals

Minerals have been loosely classified as substances obtainable from the earth by mining. The minerals needed for plant and animal growth have been dealt with in the section on food, and the fossil fuels in the discussion on energy.
For the rest, two types of approach suggest themselves.

First, one can use alternative materials. The plastics provide a whole range of synthetic materials with a multiplicity of uses. They are convenient and can be designed to meet specific needs. They pose, however, a disposal problem because many are not bio-degradable. As importantly, the production of plastics demands much energy. Once again, therefore, the necessity to make decisions based on priorities is evident — is the use to which the object is to be put more important than saving energy? One must weigh the difference between valves for heart surgery and containers for garbage disposal.

Second, one can make more economical use of what is available. This may be either through recycling techniques, or by designing commodities for quality, strength and long life. Either of these adjustments requires a tremendous modification in human attitudes.

Figure 24: Three Stages of Treatment for Sewage and Similar Organic Waste*



*Source: Odum (1971) p. 436

Recycling carries the advantage of using 'waste' as raw material, thereby reducing the use of new material, as well as alleviating the disposal problem. In the United States, for example, an estimated 70—85 million tons of iron are recovered annually from scrap, and recovery of mercury and precious metals like gold and platinum is high.

One cost factor attendant on recycling is, however, the energy output necessary for the technology of the recovery processes. It has been suggested that energy savings would be more if goods were designed to last longer. Presently, there exists a pattern of 'throwing away' old models in favour of a continuous stream of new ones. This is very well exemplified in the motor car industry.

The ultimate saving in both minerals and energy would be the designing of less energy consuming technology both for extracting minerals from their ores, and for their subsequent conversion into goods for human use.

Meeting the neeed for water

Solutions to the provision of an adequate water supply seem to centre around four strategies:

i) reforestation measures, coupled with preventive legal steps to halt the destruction of forests. This would help to protect the watersheds and keep the cycle of water moving, through increased transpiration.

ii) seeking wherever possible to 'clean' surface water, like rivers, which have already become polluted by chemicals and detergents, and to prevent further pollution. Eutrophication processes can be reversed.

iii) the development of new technologies which would reduce the requirements of industry. For example, it takes about 110,000 gallons of water to make one ton of steel. (Goldstein 1976).

iv) recycling supplies: this would apply particularly to sewage and similar organic waste. Figure 24 shows the steps in such a process. The closed system of recycling water makes the approach desirable. The economic cost can, however, be very great, especially in the tertiary stage.

Solutions to human population growth and settlement problems

The intensification of environmental problems due to human population growth and settlement patterns has been stressed repeatedly.

It has been pointed out that growth problems are in response to conscious and deliberate behaviour. Population control therefore, has to be achieved in the same way — as a result of deliberate processes. It is a social undertaking. The task calls for total public education regarding the issues, and awareness and practice of family planning measures. Religious teachings, social customs and biases counter these efforts — but the efforts must continue. The tendency exists for populations to drift into the cities, due in some measure both to the 'push' provided by the reduction in the labour pool required for agriculture, and to the 'pull' generated by the expectation of a better quality of life in the city. Some steps must, therefore, be taken to reverse this trend. Public education must emphasize the interdependence of rural and urban areas to efface the current feeling that the city is more important than the rural areas, and that the former is therefore the place to be. Economic and political decisions must be taken to provide employment and basic living amenities in rural areas to halt the drift to the cities.

Further, wherever new villages or towns develop, land use should be planned not only for productivity in terms of life sustaining systems, but for preserving the ecological integrity and

enhancing the aesthetic qualities of the environment. The same considerations should apply in establishing communication links. There is, for example, a 6 000 kilometre long motorway being built in South America from the Atlantic to Peru. To facilitate this, a large area of the Amazon rain forest, estimated to be about the size of Great Britain, is being cleared of trees. In anticipation of the usefulness of the motorway as a new trade route, other areas are being burned for the laying out of coffee and rubber plantations. The Amazon rain forest area is one of those mature and stable ecological systems which serve a global protective function — and should not be disturbed. The consequences of upsetting such a large ecosystem will be immense. In particular, the possible effect on atmospheric oxygen level should be considered.

Such planning presupposes familiarity with ecological principles, and sound knowledge of the existing interactions and trends which characterize the biotic, abiotic and sociocultural environments in any given area, and how they relate to the global situation. Monitoring exercises on a continuous world basis would, therefore, seem to be a necessity. Monitoring has been defined as:

> a system or regular synoptic observations in a space-time series, designed to give information about the environment (global, regional, national or local) so that the past and existing states can be assessed and future trends predicted in any environmental features which may be important to man.[1]

Such observations involve scientific measurement, for example, of levels of important pollutants in soil, air, water, living things and the extent of the harmful effects of these pollutants on living things. They might also include inventories of climatic changes or the effect of human impact, for example, the deforestation mentioned above, or desertification, use of resources, or species depletion.

Thus the strategy would, in fact, provide the information on existing states and forecast of future trends which would make it possible to posit the efficacy of proposed alternatives for dealing with environmental problems.

Another important concept which can and should provide an effective basis for the prevention and solution of environmental problems, is the recognition of limits. The principle is one which operates in nature: within any ecosystem, there are limits to the size and nature of the populations which may be maintained. Such limits are set both by the non-living components of the system, and by the way the living components interact. This recognition of limits should be embodied in laws which would direct human activities in ways which would make for environmental stability.

The implications are heavily socio-economic, decidedly political and involve a thorough examination of values and priorities. Growth and development have to be considered in terms other than the possession of more and more material goods. Economists have to be persuaded of the function of the natural protective systems in maintaining economic systems. Thus land which is not used for agriculture or housing would not be seen as 'idle' land. Legal measures would require the producer to bear the costs of pollution from factories etc. which are currently being borne by society at large. Industrial development projects would have built into their systems devices for controlling pollution as a requirement by law, without which they would not be allowed to operate.

Laws protecting the flora and fauna of a region should be enacted and rigidly enforced to help to stem the tide of species extinction. Such laws should go hand in hand with strictest requirements for the use of the landscape for mining, housing developments, industrial complexes and the like.

Many countries already have such laws, but all should. Further, their global implications need to be understood by all. For example, high level emissions of sulphur dioxide from factories

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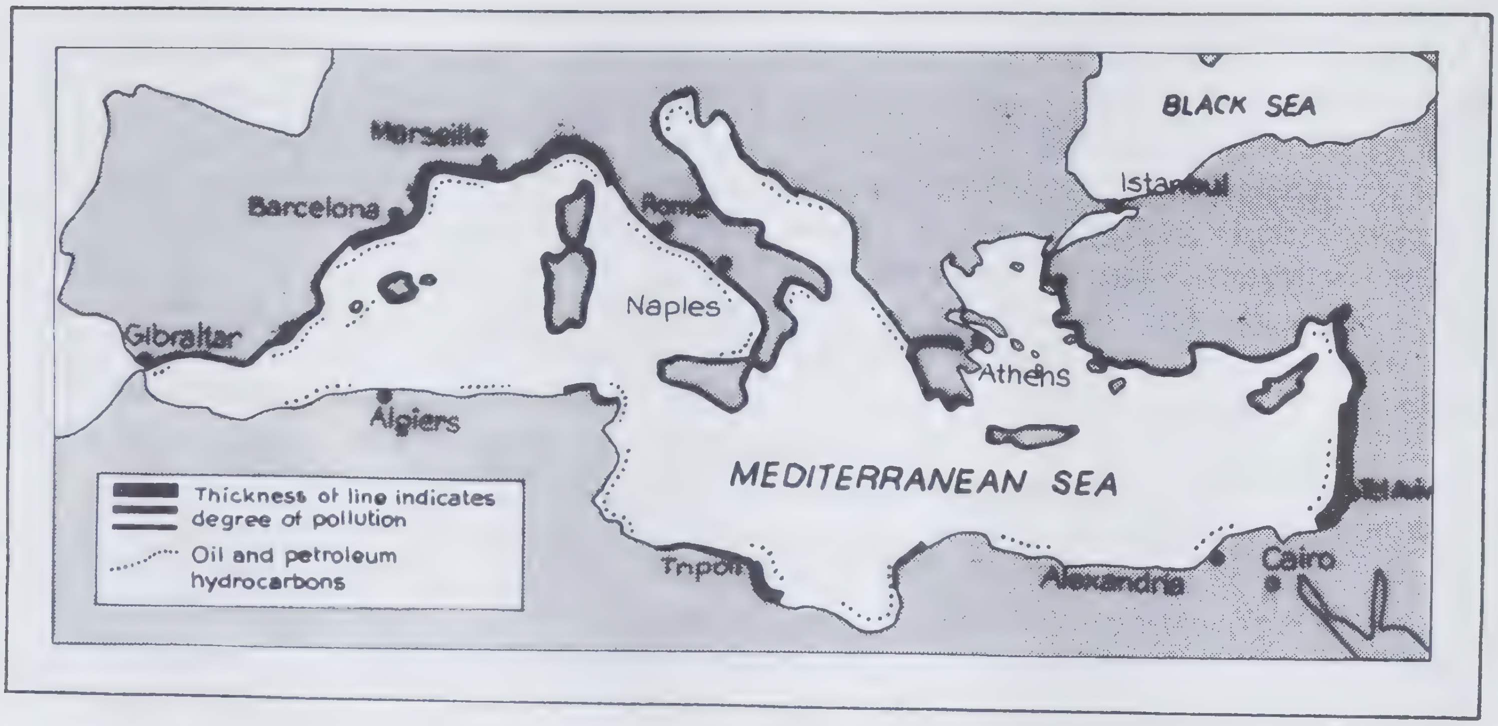
[1] Man and the Biosphere Programme 20, p. 10.

in the United Kingdom, while not contributing significantly to ground level concentrations in the vicinity, affect the environment up to two hundred miles downwind. The effect of these emissions is becoming evident in Scandinavia in the acidity of rivers and lakes. Acid also corrodes the granite of the mountains, bringing about a faster rate and stronger effect of disintegration of the surfaces, and destroying some of the oldest works of art in Scandinavia — 4–5 000 year old rock engravings of people, animals and ships cut into the sides of the mountains.

International co-operation is, therefore, essential if the establishment of legal limits is to have the expected outcome. Indeed, there are some areas, for example, the sea, that can only be dealt with on an international basis.

That this can be done successfully, once the correct attitudes have been engendered, is exemplified by the agreement at a recent (May 1980) UNEP sponsored conference among all eighteen nations bordering the Mediterranean (except Albania) to draft a treaty outlining ways to clean up the highly polluted body of water. Figure 25 below showing the relative degree of pollution in the different areas, indicates that France, Spain and Italy are the heaviest polluters. They will bear the heavier share of the cost of the $10 billion programme for cleaning up the sea.

Figure 25: Pollution in the Mediterranean Sea: Relative Contribution of Surrounding Countries



The proposed treaty calls for the banning of certain substances, e.g. mercury, cadmium, radioactive materials, and for recognition of specified tolerance levels for others. Existing and new factories and sewage systems have to conform to treaty specifications for the installation of anti-pollution devices. One important factor which contributed to international agreement was the recognition of the necessity of the measures for the healthy economy of the region. The view is expressed that a similar emphasis at the Inter-governmental conference on an Action Plan to preserve and manage the Caribbean environment (April 1981) made for the success of the conference and the decisions taken.

These observations underscore the immense importance of man's perceptions of his economic and social needs on the fate of the total environment. It is a recognition that there are social, as well as physical limits to growth, and gives pause for reflection on current values and value systems, which have been directed by the concept of unlimitedness – unlimited production, unlimited consumption, unlimited resources and an unlimited capacity by the environment to absorb waste.

This style of existence in an industrial society is creating more problems than solutions. Consequently there is need for change. Bybee (1979) suggests that basically such change involves a moving from the **having** mode of existence of industrial man where quantity is the keyword, to a **being** mode of existence, where quality of life is the important focus. He equates this mode of existence with the development of a society where ecological concepts form the new basis for development. As he puts it, the conceptual successor to the industrial society is the ecological society.

> ...when it is necessary to subsist on the products of the land and the survival of children is low, we had to have 'dominion over nature' and to be 'fruitful and multiply.' The challenge was to survive and humans adapted accordingly. The next challenge was the development of technology to meet the needs of society. The result has been the highest level of affluence in human history. But the effluence from our society has also been the greatest in history and now this unintentional consequence must be remedied... The concerns have turned from the need to conquer the natural world in the first case, and the need to master the man-made world of technology in the second case. Presently our need is to understand ourselves and our earth systems. (pp. 106, 107).

Environmental problems have their origins in human ideas and values: it is also in the realm of these ideas and values that solutions will be found.

Methodology for environmental education

CHAPTER 5

Strategies for including environmental education in the curriculum

In practice, the application of the philosophy presented, means that environmental education will be taught by methods which, in some way, satisfy criteria for interdisciplinarity. The infusion method, the Applied Learnings method and the Holistic method are considered applicable.

The infusion method

This is implemented by adding a new focus to a discipline. This new focus calls for deliberate selection and inclusion of content which will add to the students' awareness and understanding of the environment and environmental issues. Student attention is probably best focused by raising questions which will demand a search for hitherto unnoticed meanings, or which will highlight important aspects of environmental learnings.

It will be necessary for the specialist teacher trainer to draw on the expertise of colleagues in the preparation of courses and lessons. Indeed this is imperative, and it is in this way that the infusion method satisfies criteria for classification as interdisciplinary.

Religious knowledge

Religious knowledge has already been identified as one of the major contributors to the formation of attitudes towards the environment. It deals with those intangibles which some philosophers see as the central core of man's existence — spiritual values and moral systems.

In a course on comparative religion, examination of the teachings and references to the relationship of man to his environment present in other religions should form the basis of a comparative assessment of the contribution of each, which should be regarded as imperative. Cultural practices with a religious base — rites of planting and reaping, fertility rites, the choice and naming of deities — reveal beliefs and philosophies of older societies than ours. The information is not only fascinating in itself, but forms a basis for assessing our beliefs and practices and probably for strengthening them by adding new meaning to them.

Literature and language

Literature, in any language, is one way of passing on the cultural heritage from one generation to many others that come after it. In the literature is contained the tales, myths, legends and stories which express the thoughts and feelings of mankind towards his social and physical environment,

his values, his aspirations. Studies of novels, poems, plays, could include the extraction of awareness of the environment, perception of the environment, knowledge about the environment, use of the environment in setting moods and atmosphere which suggest an interpretation of the environment. Creative writing could be directed to the environment in which the students live or have experienced.

Art and craft

In nature there is no wastage: there is constant recycling of materials, and this can be practised in art and craft to build environmental awareness and to imitate the patterns of nature. Through art and artistic observation and expression of nature, the teacher can build a deep appreciation of the beauty of the physical surroundings and draw attention to those aspects of the social environment which are in need of change since they are out of harmony with the beautiful and the harmonious.

Physical education and dance

As in the case of literature, this is an area of cultural expression and cultural preservation. Understanding and performance of traditional dances enhance the meaning and appreciation of certain traditional customs and build international understanding through recognition of those principles of cultural activity which are common to all mankind. The physical education and dance course is thus conceived as having a theoretical and factual content as well as the 'laboratory' of practical experience.

General science

The sciences are so closely related, not only to the physical and biophysical environment, but through technology to the economic and social, that it is easy to believe that the teaching of science is also the teaching of environmental education.

Like other subject areas, however, science needs to be given an added dimension. The dynamic equilibrium which is the hallmark of all physiological processes and ecological systems — in other words, the 'give and take' in nature; is a concept which must pervade all teaching. In the process of obtaining food, shelter, goods, and medicine, man must constantly maintain this equilibrium with his physical and biological environment. Therefore, a study of nature must serve to indicate strategies for survival which man can use to best advantage.

The precision and objectivity of the scientific experimental approach so essential for meaningful investigation and isolation of variables, though it informs man's relationships with other men and with the total environment, must not totally direct them. Environmental education demands that parallelling the training in acquiring this kind of objectivity, must be the cultivation of the ability to make informed value judgments on issues pertaining to science and technology.

Economics

Economics is concerned with the use of the resources of the earth, the distribution of material wealth, the various systems into which the process can be organized. Into such a content area one needs only to interject —

Stage of Model	Consideration	Disciplines
1. Preliminary, factfinding investigation	How the problem originated: – the sugar cane, cultivation and reaping patterns – manufacture of sugar and rum, inputs and outputs of processes:	History Agriculture Economics Chemistry Economics

Input	Product	'Waste'	'Waste Disposal'	
cane juice →	sugar →	molasses →	cattle feed rum	Engineering Physics
molasses →	rum →	dunder →	river fertilizer	Ecology Chemistry

Stage of Model	Consideration	Disciplines
2. Interpretation and Planning	Determine whether alternative found out in research is desirable or suggest another Outline programme of action	Values clarification Agriculture Ecology
3. Implementation	– approach civic/legal authorities for support – approach owners of sugar factory – present data on problem – enlist cooperation in substituting more desirable alternative – follow up to ensure implementation	Law Civics English
4. Evaluation	– monitor river, keep records of water quality, plant and animal life – present regular periodic reports over time until desired end is achieved	Ecology Chemistry Mathematics Art

FEEDBACK

a) an emphasis on and a concern for the wise use of resources, and a more equitable distribution of material wealth
b) a recognition of the economic and therefore social origin of many technologies which, while carrying benefits, also result in problems for the environment, e.g., the manufacture of synthetic detergents to replace soap.

Applied learnings

The applied learnings method uses a thematic approach to problem-solving to complement the separate disciplines approach.

The problems for the exercises must be drawn from real life — of the community in which students live or from any other community where the problem exists or existed in the past. The object is to use the knowledge acquired in separate discipline teaching to fully analyse the problem and its implications, propose and examine the consequences of each solution proposed and, on the basis of established criteria, select the solution which will make the best answer to environmental concern, and suggest plans for its implementation. In other words, students would be applying the model proposed earlier (see page 71) for finding solutions to environmental problems.

Research in history or contemporary activities should provide exemplars of the consequences of certain solutions and assist in the selection of appropriate alternatives. The objective should always be the establishment of dynamic equilibrium in the system.

Applied learnings are clearly interdisciplinary in approach and may well require the co-operation of several members of staff in a team teaching situation.

This necessitates considerable pre-planning in order to make the best use of the talents of all staff members in academic as well as organizational ways. The method, because it is problem solving in approach presents an excellent way of involving the community in the 'team' since it is likely that there may be areas (e.g. law, engineering) where staff members lack expertise.

The community and action-oriented trend which should be a bias of environmental education, would thus be maintained.

Consider, for example, the problem of the pollution of a local river by dunder, the waste left after sugar is extracted from the juice of the sugar cane. The scheme following illustrates the several disciplines on which students would have to draw in order to adress the problem.

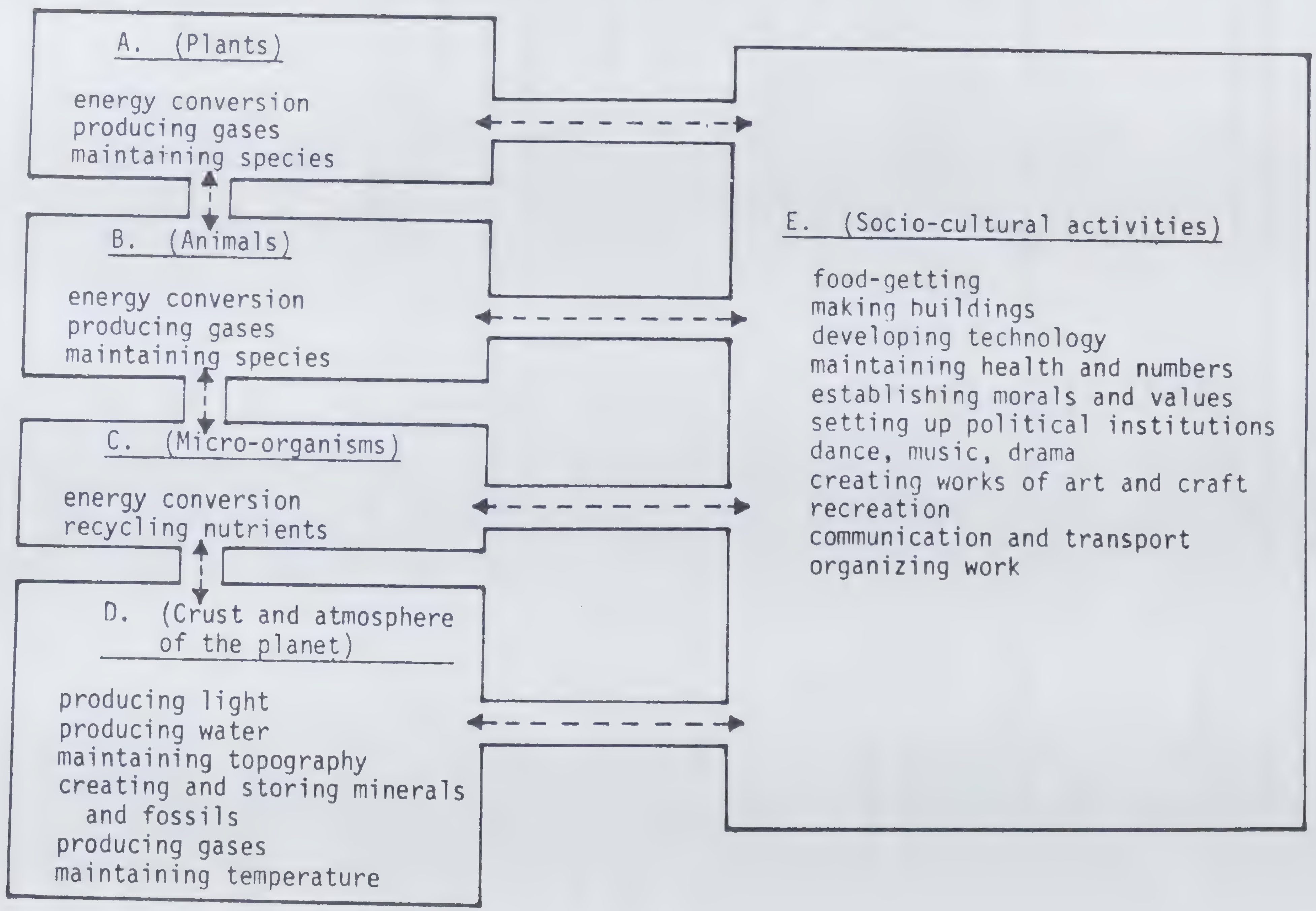
The holistic model

The holistic model aims at capturing the spirit as well as the letter of environmental education. Of the three approaches described, this one carries the best expression of the totality of the environment and of the variety of disciplines which contribute to its understandings. It can be used to study a defined physical area of any size in which the activities named in the model are performed. Thus it could be applied to a home, a town, a country.

The ultimate aim must be to evaluate the 'ecological health' of an environment. Using a mature ecosystem as a yardstick, an assessment could be made of the total environment and corrective action could be identified, planned and implemented.

The model (Figure 26) represents the environment as a dynamic system with a number of cells each of which contains a group of activities. All the activities in each cell are related to each other and there are relationships between cells.

Figure 26: Model for holistic study of an environment



By using this model the student should be able to
i. state the composition of an environment
ii. show that an environment is dynamic through the use of diagrams and descriptions
iii. give the meanings of 'ecological health, biosphere etc.
iv. make an assessment of the ecological health of an environment
v. state criteria for 'good ecological health'
vi. make recommendations to improve the ecological health of an environment or part of an environment.

All the activities listed become topics about which data must be collected; the two way arrows are direct relationships which must be explained. Support, constraint, change are considered to be the nature of the relationships.

Data collection

The Commonwealth Caribbean was selected as an appropriate area to be used as an example of how to use the model partly because it is an area familiar to the writers and partly because it is a sufficiently small area consisting of many islands — communities somewhat compact and isolated — to allow easier observation. Also, these territories have become home to peoples of all the major continents of the world for near two thousand years A.D. and for a considerably longer time B.C. A chronological approach to the study of this environment should yield a fascinating story of changing physical and social environments as each successive wave of migrants settled and reacted with each other and with the physical environment. For purposes of the study a short time period has been selected — 1494 to 1650, the period when the islands of the Commonwealth Caribbean were occupied first by Amerindians and then by Spaniards.*

The Commonwealth Caribbean are all those islands and mainland territories whose shores are washed partially or wholly by the Caribbean Sea, and which are English speaking. The region could, however, be treated as a whole, and this restriction must be seen as one entirely of convenience both in respect of time, volume and available texts. The areas are considered sufficient to examplify all the main and important ideas of environmental education.

The Amerindians

Making settlements and buildings

Three nations of Amerindians are known to have settled in the area now called the Commonwealth Caribbean — Arawaks, Caribs, Siboneys. Little remains of the Siboney occupation; they seem to have left before the Arawaks and Caribs came or soon after that. The areas settled by the Arawaks and Caribs are shown on the map following.

The Amerindians made their settlements in coastal areas, never moving too far from the sea on which they depended heavily for food. They seem to have preferred the low hills near the sea from which they had a commanding view of both the sea and the surrounding land. The sizes of the settlements varied among the Arawaks, from a one family community to large communities of up to fifty related families.

*The model could equally well be applied to this region over the period 17th to 20th century or to 20th century alone. For convenience and for making comparisons the 17th to 20th centuries could be subdivided into significant periods.

Figure 27: Arawak and Carib Settlements
Source: Claypole and Robottom (1980) (p. 5)

Arawaks and Caribs gathered their building materials from the surrounding forests: poles, wild cones, withes, thatch. The Arawaks built small round huts with cone shaped roofs; the Caribs wove the thatch into a house shaped more like a beehive with the roof reaching nearly down to the ground. The Arawak houses were all shaped alike except for that of the cacique (chief) whose house was rectangular in shape and might have several (rather than one) rooms. Arawak huts were said to be capable of withstanding very strong winds and hurricanes. Structures were used as temporary shelters, since the Amerindians moved from one location to another as soon as their type of agriculture exhausted the soil.

The Amerindians named the places in which they lived; Columbus reported that present day Jamaica was called YAMAYE.

Food-getting

In order to get food, the Amerindians combined fishing, hunting and agriculture. Agriculture was practised at subsistence level, using a slash and burn method. Trees and bush were cleared away by burning and seeds were planted. It is reported that the Amerindians introduced food crops from the mainland territories from which they migrated. They brought with them the cassava, maize, sweet potato, arrowroot, peas, beans, pumpkins, hot peppers. Their diet included guava, avocado, naseberries, pineapples, but these may have been indigenous plants of the islands.

Hunting was limited to small land animals like iguanas, conies, rabbits, agoutis. The manatee and pedro seal were sea animals which were harpooned. Wild ducks, parrots, doves were caught by nooses, nets and snares. Ingenuously, an Arawak, on sighting wild ducks in the water would float dry calabashes downstream towards the flock. As soon as the birds had accepted the presence of the calabashes, the hunter covered his head with one in which breathing holes had been made. He then swam to the birds, caught them by their legs and pulled them quickly under water to drown them.

Fish, shell fish, turtles were caught by the fishermen. They used nets made of plant fibres and hooks of bone and turtle shells. In Jamaica and Cuba the Arawaks also made use of the remora or sucking fish. The remora was tied to the canoe and carried out to sea. As soon as it attached itself to a fish, it was pulled alongside and the fish was removed. The Caribs are said to have made use of the poisonous bark of a tree. It was powdered and thrown into the water, its effect being to stun the fish. Columbus is said to have reported in this way:

> ...I have no doubt that they sow and gather corn all the year round, as well as other things... Here the fish are so unlike ours that, it is wonderful... I saw neither sheep, nor goats, nor any other quadruped...[1]

Developing technology

The Amerindians of the Caribbean made their tools, weapons, furniture and utensils from stone, bone, turtle shell, coral, wood clay.

From the stone, they shaped and polished axes, chisels, pestles, ornaments and beads. The Arawaks achieved a high degree of skill in the use of stone.

Bones and turtle shells were reshaped to make fish hooks, needles, tips for harpoons. Clay was fashioned, by hand, into unglazed, incised pots and baking stones. Wood was made into a pointed pole used as the only agricultural implement and into seats for the caciques — DUHO. The stout trunks of the silk cotton and of the cedar trees were also used in the building of canoes. The tree was felled with the assistance of fire. The trunk was charred to begin the process of hollowing, the job being completed with axes and chisels. The canoe was shaped by wetting it and inserting wedges of varying width. The canoe was buried in wet sand to cure before being dried in the sun. Canoes were made to carry one person or up to fifty persons. Arawak canoes were carved and painted.

The Arawak women spun and wove the indigenous cotton into cloth and nets for hammocks. Sometimes the cloth was dyed using natural dyes from the barks of trees. A little gold was found in the islands, and the Arawaks made these into nose plugs and ornaments for their caciques. It was obtained from the rivers by digging holes at the side of a rapid part of a river. As the water flowed through, a certain amount of silt was deposited. If any gold was seen, the silt was removed and washed to separate the gold from the silt. One writer reports that the gold was hammered into shape. Feathers of indigenous birds were woven into cloaks and headdresses — apparently for noblemen.

For domestic use, graters and juice squeezers were made. The Amerindians perfected a process for removing the poisonous element from the juice of the cassava and making a non-poisonous preservative called cassareep which was used in cooking meat. The Arawaks have the distinction of being capable of making a basket for carrying water. This they did by double weaving leaves and wood.

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[1] Cited in Williams, Eric. Documents of West Indian History 1492–1655 (p. 19).

Arawaks and Caribs used wood to make weapons — the Arawaks made a wooden club called a mocuma, the Caribs made clubs and spears of various types. One Carib club, the butu, was inset with sharpened flints.

Arawaks and Caribs depended solely on human energy for their everyday tasks and used hand tools to maximise the output. They used it also for powering their canoes between the islands and the mainland. Maximising tools were paddles.

Communicating, migrating, trading

Amerindian canoes plied between the islands, the South American continent and the Central American lands. Arawaks are reported to have reached as far as the Bahamas and the Yucatan peninsula. Trade was generally by barter, but the Caribs used tobacco as a form of currency. Items bartered were tools, weapons, furniture, tobacco, fruits, gold.

Caribs and Arawaks moved into the Caribbean islands from the mainland Guianas, and they relied on their canoes for this migration.

Making friends and enemies

Caribs and Arawaks were continuously at war. The Caribs are said to have pursued the Arawaks through and out of the Eastern Caribbean islands — the Lesser Antilles — into the Greater Antilles. The Caribs raided the Arawak settlements, capturing women as wives and eventually executing the men. Both groups settled in Trinidad, the Arawaks in the south maintaining their position by the assistance of allies called Nepoyas.

Maintaining health

Information under this heading is confined to the Arawaks. They practised a form of medicine which was a mixture of the use of herbs and of other ways of counteracting the anger of spirits. Some cures were effective. Excavation of Arawak remains shows a prevalence of arthritis and of dental caries.

Domestic waste was piled in heaps, today called middens; dead persons were buried sometimes in caves.

Regulating society and making decision

The Amerindians had a clear leadership system: each village had its own chief or subchief responsible to a chief. Villages were sub-units of provinces. A large village had a chief and a council of noblemen — nitayanos. Some nitayanos were priests who supervised religious rites and trained medicine men. The history and laws of the group were taught to the young through songs and dances.

The position of cacique was hereditary among the Arawaks. Caciques were greatly respected and carried special privileges.

Land was held in common among the Amerindians. Labour was divided according to sex and age; marriage was customary.

Figure 28. Audiencias of the Caribbean

Source: Augier F. R. (1960) **et al.** The Making of the West Indies.

Establishing morals and values

The religions of both included ancestor worship, belief in gods and spirits and in a life after death. The Arawaks are known to have had myths which explained the origin of the world, of man, of the oceans and fishes. The myths contained the notion of punishment by gods for disobedience of rules. For the Arawaks, heaven, COYABA, was a place without droughts, hurricanes and sickness, where people spent their time feasting and dancing.

For the Caribs, heaven for brave souls was a place where they were waited on by Arawaks. Sea spirits were prominent in Carib religion.

Playing games, dancing and making music

Dancing and music appear to have been an integral part of religious festivals. Games on the mainland were played in a special ball court, but its significance was different from sports of today. No information has been found on the Caribs, but it is known that the Arawaks called theirs batos. Players of an unspecified number, mixed or single-sexed teams, played against each other. A ball was used. The object of the game was to hit the ball from side to side using the shoulder, hip or knee, but never the hands. If the ball fell 'dead', a point was scored against the side which should have hit it.

Use of tobacco

The use of tobacco was significant in society. It was used as part of religious rituals and apparently by individuals for personal reasons. The Arawaks used a Y-shaped pipe, both branches being inserted into the nostrils. Smoke was, in this way, deeply inhaled and soon produced unconsciousness.

The Spaniards

Making settlements and buildings

Columbus and his sailors arrived in the Caribbean towards the end of the fifteenth century, but it was not until the early sixteenth century that settlers — colonists — arrived. In the Commonwealth Caribbean, they settled in the Greater Antilles and in Trinidad, in areas occupied by Arawaks; the warlike Caribs had probably been more successful in fighting them off.

Columbus' description of the West Indies gives a useful indication of how a Spaniard saw these islands:

> Tuesday, 16th of October
>
> ...I saw many trees very unlike those of our country. Many of them have branches growing in different ways and all from one trunk, and one twig is one form, and another in a different shape, and so unlike that it is the greatest wonder in the world to see the great diversity; thus one branch has leaves like those of a cane, and others like those of a mastick tree...
>
> Friday, 19th of October
>
> ...I can never tire my eyes in looking at such lovely vegetation, so different from ours. I believe that there are many herbs and many trees that are worth much in Europe for dyes and for medicines; but I do not know them, and this causes me great sorrow... I found the smell of the trees and flowers so delicious that it seemed the pleasantest thing in the world...
>
> Wednesday, 14th of November
>
> ...he saw so many islands that he could not count them all, with very high land covered with trees of many kinds, an an infinite number of palms. He was much astonished to see so many lofty islands; and assured the Sovreigns that the mountains and isles he had seen since yesterday seemed to him to be second to none in the world; so high and clear of clouds and snow, with the sea at their bases so deep...
>
> Sunday, 16th of December
>
> ...This land is cool, and the best that words can describe. It is very high, yet the top of the highest mountain could be ploughed with bullocks; and all is diversified with plains and valleys. In all Castile there is no land that can be compared with this for beauty and fertility... Your Highnesses may believe that these lands are so good and fertile, especially those of the island of Espanola, that

> there is no one who would know how to describe them, and no one who could believe if he had not seen them...
>
> Friday, 21st of December
>
> ...I have traversed the sea for 23 years, without leaving it for any time worth counting, and I saw all the east and the west, going on the route of the north, which is England, and I have been to Guinea, but in all those parts there will not be found the perfection of harbours... this one is better than all others, and will hold all the ships of the world, secured with the oldest cables... This port is very good for all the winds that can blow, being enclosed and deep... Any ship may lie within it without fear that other ships will enter at night to attack her, because although the entrance is over two leagues wide, it is protected by reefs of rocks which are barely awash... It is the best harbour in the world, and the Admiral gave it the name of Puerto de la Mar de Santo Tomas, because to-day it was that Saint's day. The Admiral called it a sea, owing to its size.

Emigration from Spain to the colonies was controlled to ensure that the interests of the Crown were served. Though settlers came from many walks of life, it was eventually recommended that only Catholics from Castille should be allowed to emigrate. There were peasants, soldiers and sons of the lesser nobility seeking fortune, an easier life, wealth. All came to the colonies as landowners, receiving grants of land, with the Indians on it, from the King and Queen of Spain. Forced labour became the order of the day and the resident Arawaks worked in the mines and in agriculture for the Spanish landowners.

In Jamaica, the Spaniards became ranchers and suppliers of fresh food to Spanish ships on their way to the Main. Trinidad was used mainly as a base for attacking the mainland, but there were a few colonists. In 1634 their number was reported as twenty-six. The number of Ame-indians was given as four thousand. Little detail is known about the architecture of the time, but from fragments found in Jamaica (carved stones and half columns) it is clear that it was European in style. Remains of the first attempt at an urban centre made in 1510 contain a fort, a fortified castle and a church. This town was found to be unhealthy since it was built near the swamps. It was so unhealthy that only ten children of those born in a twenty year period are said to have survived. The Spaniards moved to the south coast to a healthier location.

By about 1643, a main town in Jamaica was said to consist of four or five hundred houses, five or six churches and chapels and a Franciscan monastery. Houses were made of wood and tiles and some of brick. They were usually one-storied because of the threat of earthquakes. In the main town, houses were made of bricks or of wood and tiles.

Living in the main town were the government officials, merchants and high officials of the church.

Food-getting

The Spaniards learned from the Arawaks how to use cassava, maize, cocoa, tobacco, sweet potato. They introduced the cultivation of bananas, plantains, oranges, lemons, figs. They grew sugar cane and produced sugar for local consumption. Grapes were cultivated and wines were made. Goats, cattle and pigs were added to the fauna.

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[1] Williams, Eric Documents of West Indian History 1492–1655 (pp. 5, 6).

From Spain, they imported clothing, wine, oil, wheat flour and a few other luxuries. Over the years, the island settlers were forced more and more to rely on what could be cultivated there. A Spanish resident in Trinidad in 1613 complained that in eighteen years he had not seen a single Spanish ship with which to trade, and he requested two ships per year each of two hundred tons capacity to bring food and other necessary things. In 1653 the situation had not improved; the settlers had been unable to send their goods to Spain since the 1630's.

There is no clear statement that the Spaniards used fish or that they hunted as the Arawaks had done.

Developing technology

The Spanish settlers used the same method as the Arawaks for getting gold out of the rivers, but they are supposed also to have opened mines for that purpose. One such mine is supposed to have been at the eastern end of Jamaica.

Sugar cane was crushed in horse-drawn mills and the juice was boiled in copper troughs to convert it into sugar.

There were tanneries in which goat skins were made into excellent leather.

The weaving and dying of cotton cloth continued; there is no clear evidence as to whether this was Arawak or Spanish in process, though Spain is known to have developed special skill in this.

Some shipbuilding was done in the islands using the cedar and mahogany trees. Large ships of Spain were fitted with square sails; small ships with triangular sails. Perhaps the settlers used these designs.

Communicating, migrating, trading

Communication, migration and trade were maintained by sailing ships. Settlers were expected to trade directly with Spain, and this trade was monitored and regulated by the House of Trade in Spain.

Within the territories, walking trails and bridle paths linked the settlements.

Because supplies of goods were not sufficiently varied nor sufficiently frequent, the settlers soon turned to trading with Spain's European rivals — the French, the Dutch and the English. The following report is informative:

> To Puerto Rico went that year (1625) two ships... to Jamaica two... all laden with wines, figs, raisins, olives, oil, cloth, carsies, linen, iron, and quicksilver for the mines.[1]

Shortages led to purchases of the following from Spain's rivals: hardware, tools, weapons, books, paper.

The Spaniards used a copper currency of no fixed value.

There was some forced migration of Amerindians between the islands, but this was ended by the Crown.

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[1] Thomas Gage, A New Survey of the West Indies 1648. 1946 ed. London p. 14 cited in Williams, Eric (op. cit.).

Making friends and enemies

The Spaniards were, at first, hospitably received by the Arawaks; the Caribs regarded them as intruders from the very beginning. Once they settled and enslaved the Arawaks, hostilities developed and some reports indicate that there was stout resistance by the Arawaks. The Arawaks lost not only their freedom, but eventually their lives.

The Spanish colonists, neglected by Spain, nonetheless found themselves targets in the continuing harrassment of Spain in the Americas by England, Holland and France. The islands were often raided by pirates, sufficiently frequently to make the settlers 'nervous and terrified'. By 1609, only the two islands occupied by Spain were recognised by the other three as Spanish. The others were considered open for settlement.

Spain maintained control over her colonies through the Council of the Indies formed in 1524. But the colonists found that their interests and those of Spain were not always identical. Spain recognised the difference and potential differences. Consequently the people of Spanish descent born in the New World (creoles) were not usually appointed to any office. Of seven hundred and seventy two such posts, only eighteen went to creoles.

Maintaining health

(The texts consulted are deficient in this type of information. Since medicine was being taught in universities in Europe at this time, then doctors in the Caribbean, if indeed any came, would undoubtedly have applied their learning. It would therefore be useful to consult texts relating to Spain at this period.)

It can be noted here, however, that the Spaniards' response to the unhealthy, swampy, location was simply to move away from it.

Regulating society and making decisions

The regulation of the society and the making of decisions were firmly in the hand of Spain, and there the interests of the Church, the Crown and the settlers were resolved. The Spanish empire in the west was divided into four vice-royalties each administered by a Spanish viceroy. Each vice-royalty was divided into audiencias, each of these administered by a council of lawyers from Spain. The Caribbean islands lay in the Audiencia of Santo Domingo. The lawyers of the audiencias heard complaints of settlers and of Indians and Africans against settlers. Each audiencia was further subdivided into provinces, each ruled by a governor, whose main duty was the collection of taxes. Governors were assisted by a cabildo — a council of nominated members.

An interesting example of the clash of interests between the Spanish and creole concerns happened in Jamaica in 1655. When the English raided the Spanish capital, the governor surrendered the country. The creole, Ysassi, was totally opposed to this action and carried on the fight with the English for several years. The islands was virtually divided in two camps — English on the South coast and creole Spaniards on the north coast.

Establishing morals and values

The Spaniards belonged to the Roman Catholic sect of the Christian religion. The Spanish Crown supported the Church with grants of land, free wine and oil, and free passages for priests. The

church ministered to the needs of the settlers, and its mission to the Amerindians was to make them into Christians. The power of the Church was supported by a branch of the Spanish Inquisition.

The church in Trinidad and Jamaica was made responsible for the welfare of the Indians. They received some instruction in the Spanish language, religion and crafts. The church also built schools and hospitals.

The priest Bartolome de las Casas is well known for the work he did in resolving the burning human relations problem of the day — the relationship between Spanish settlers and Amerindians, and later the relationship between Amerindians, Africans and Spaniards. His position, as Protector of Indians, was anti-slavery, and he urged the Spanish Crown to adopt this view. But it was difficult to monitor the settlers and they found that their interests were best served by slavery, first of the Amerindians and then of Africans. The value conflict in this society as a factor in the social environment should be studied in detail.

Playing games, dancing and making music

Spanish colonists are reported as having entertained themselves with dances, ball games, tournaments of various kinds. Card-playing was also a sport.

Learning and research

Spaniards in the Caribbean may have heard the new theories about the nature of the planet in Spain. Columbus himself had accepted the theory that the earth was round and set off westward confident that this was an alternative route to the east. This explains the naming of the Caribbean as the Indies. But Columbus was not typical of the people of his home — the sailors on his ships had no such conviction, and this led to near mutiny on the long voyage. We may conclude that anyone connected to the Spanish court and any who had been at the universities of Spain were more likely to have this knowledge than others.

Texts consulted do not give any information on the education of Spanish children in the islands, but the settlers did purchase books and paper.

Interpretation of data

It has already been pointed out that the amount of light and water available in an environment has a direct influence on the flora and fauna of the area. Food, essential support for man, is usually selected from what is available in the area. The flora therefore imposes some constraint on the food man may include in his diet.

Question 1

Read again Columbus' description of the West Indies. Are there any clues to the 'ecological health' of that ecosystem? Find out, by research, the climate of Spain and the plants which grew there in the fifteenth century. Describe how the Spaniards responded to the West Indian environment so far as their diet was concerned. Assess the effects of that response on the total West Indian environment.

Question 2

The Amerindians are said to have hunted the manatee and the pedro seal. Today, these species are rare in the Caribbean. Find out why this is so. Consider both human and non-human causes. Draw a diagram to show the causes and their relationship. Do you think their absence has had a favourable or unfavourable effect on the environment? State reasons for your answer.

Question 3

Make a list of the naturally-occurring features which the Arawaks perceived and used. Make a similar list for the Spaniards. Compare the lists and explain the differences as feedback of cell E. Compare the impact of both peoples on the crust and atmosphere of the West Indian environment.

Question 4

Columbus was one of a few Europeans who accepted the theory that the planet was spherical and not flat. Do research to find out:

i. who proposed the theory, and what the supporting evidence was
ii. who opposed the theory and why
iii. The King and Queen of Spain supported Columbus' venture. How far did his reason and theirs coincide? How did this affect the social, economic and cultural dimension of the West Indian environment?

Question 5

The natural disasters of the West Indian environment are earthquakes and hurricanes. Compare the types of structures used by Amerindians and Spaniards (material and design). Assess the suitability of each people's response as solution to the problems.

Although the model is intended to be applied to one society in one location, the history of the Amerindians and Spaniards in the West Indies is a good example of two societies in a conflict situation.

Question 6

Explain how the disappearance of the Arawaks as a result of Spanish action was the result of differences between cell E of the two peoples. Show, in particular how the difference affected

i. initial perceptions of each other
ii. changes in the perception of each other (note especially the conflict within each society) and also the expression of these changes in activities of cell E.
iii. Indetify the dominant emotions of each group and assess the mental health of the environment (the assistance of a psychologist/psychiatrist will be needed).
iv. Say what changes in both societies might have prevented the disappearance of the Arawaks *and* also have created a 'good society' for both peoples.

Changes in cells A, B, C, D, occur over slow evolutionary time, while those in cell E are very rapid.

Question 7

Find out the diameter of a tree which would have to be used to make a canoe for one person and the length of time the tree takes to produce a trunk of the required size. Estimate the length of time it took Amerindians to change the tree into a canoe. This action would constitute a disturbance of the environment. Suggest the level of disturbance to which the flora would naturally adjust, and assess the chances for this adjustment

(a) while the Amerindians alone lived in the territory

and (b) when the area was occupied by both peoples.

CHAPTER 6

Pedagogical approaches to environmental education

The objectives for Environmental Education worldwide articulated at the Tbilisi Conference stressed the acquisition of an *awareness* of the environment, an *understanding* of the environment based on knowledge about it, a *concerned attitude* towards the environment, and an *ability to act* arising out of a mastery of the skills of identifying/anticipating problems and preventing or solving them.

These must, therefore, be reflected in the way Environmental Education is taught. Indicated in Table 6, are the groups of mental skills to be gained, the processes which will facilitate their aquisition and the teaching/learning strategies which may form the medium through which the desired mental outcomes might be achieved. The skills are by no means new to educators, but the grouping are named to focus attention on the aims of environmental education. Five groups are therefore suggested:

Group A — investigative, diagnostic, decision-making skills
Group B — values clarification skills
Group C — anticipatory and predictive skills
Group D — assessment and evaluation skills
Group E — action oriented skills

Certain concepts are also basic to an understanding of the environment, and should be included at the appropriate level of difficulty for the audience. These include environment, ecosystem, dynamic equilibrium, cycles in nature, homeostasis, imbalance, resources, limits, values, social responsibility. Figure 29 summarizes these ideas.

The continuous development of certain basic skills underlines the organisation of all the teaching/learning strategies. These basic skills are: reading, communicating, questioning and the inter-personal/social skills. The use of groups or teams of a co-operative rather than competitive nature should be emphasised.

The main teaching/learning strategies are discussed to show their particular contribution and suitability for environmental education.

Project work and problem-solving

To be most effective in environmental education, project work should relate to community problems, as far as possible involving the community and its people as resources and the people of the community as active participants. Project work can be undertaken by one or several groups or by the whole institution. In identifying topics or themes for research-oriented projects, it would be useful to use historical ones since it is possible to select 'completed' cases of environmental change for analysis and evaluation. These would be particularly useful in building the anticipatory

Figure 29: Summary of Skills and Concepts to be stressed in Environmental Education

Table 5: Groups of Mental Skills and Teaching/Learning Strategies for Acquiring Them

		GROUPS OF SKILLS	MENTAL PROCESSES	TEACHING/LEARNING STRATEGIES
AWARENESS	A	investigative diagnostic decision-making	observing analysing measuring synthesising	field trips experiments project work problem solving
	B	values clarification	analysing prioritising comparing	role-playing & simulation debates discussion situation analysis
UNDERSTANDING	C	anticipatory	hypothesising inferring recognising signs, trends, patterns analysing synthesising	experiments situation analysis
	D	assessment evaluation	analysing discriminating application	establishing criteria forming judgments
PARTICIPATING	E	action-oriented	planning problem identification evaluating decision-making	project work

and predictive skills of hypothesizing, inferring, analysing, synthesizing, recognizing patterns.

Action-oriented project work should seek to identify problems of imbalance in the equilibrium and be aimed at correcting these. Some examples of problems of imbalance are epidemics, floods, droughts, pests, man-made disasters, e.g., metal poisoning from factory waste.

Project work makes use of the talents of all in the working group. It stimulates the interest of students, tutors and community, and promotes interdisciplinarity. It is, however, time consuming, and the evaluation of students' work is difficult.

Example 1

Activity: Historical review of natural disasters in an area over a period of 200 years
Teaching/learning strategy: *Project*
Skill Group: A (Investigative, decision-making)
Mental processes: planning, analysing, synthesizing, prioritising, values clarification

Objectives

Knowledge: Students should be able to state
— the natural disasters in a prescribed area over a 200 year period
— the environmental effects of these disasters and steps taken to deal with them

Skills: Students should demonstrate an ability to
— interview citizens to obtain needed information
— use the library as a resource centre
— design a suitable disaster drill for use in a primary school in the event of e.g. a hurricane

Attitudes: Students should show
— a willingness to find out things for themselves
— an appreciation of the experiences of the elderly
— a willingness to consider alternatives
— a readiness to act in a disciplined way in a disaster

Outline of procedure: Students will

1) gather information from any source available, including the library, and the remembered experiences of the older citizens of the area on —
   — the nature of the disasters
   — the extent of the problems they generated
   — efforts at dealing with the problems
2) assess these problem-solving efforts for practicability and usefulness
3) suggest alternatives to them, giving sound reasons for their proposals
4) design a 'disaster drill' for a primary school to be put into operation if there is a hurricane
5) support the design theoretically, that is, show how it would help to alleviate difficulties, prevent panic and save lives.

Example 2

Activity: investigating patterns of agricultural practices in a rural community.
Teaching/learning strategy: *Project.*
Skill group: A (Investigative, diagnostic)
Mental processes: observing, measuring, analysing, synthesising.

Objectives

Knowledge: Students will be able to state
— the main agricultural products in a specified area

— the farm practices involved in their production
— the specific effect of consumer demand on production of one particular crop
— measures for alleviating environmental problems caused by farming practices

Skills: Students should demonstrate an ability to
— interview selected individuals to gain desired information
— determine by observation characteristics of a farm
— organize a seminar for 25 participants

Attitudes: Students should show
— an appreciation of the interdependence of the farmer/producer and the consumer
— an awareness of the effect of consumer demand on agricultural practices
— a willingness to make informed judgments on environmental issues

Outline of Procedure:

1) Find out from the literature or from knowledgeable individuals the main agricultural products of the region.
2) Visit selected farmers within a ten mile radius of the institution who produce these crops. (The size of the area from which information is drawn, will vary with local circumstances).
3) Find out, at first hand, by direct observation and by interviewing the farmer, the following for each farm:
   a) the size of the farm
   b) number of employees
   c) number of mechanized units (owned or hired for use)
   d) the crops grown/animals kept
   e) kind of land preparation carried out
   f) planting and harvesting seasons
   g) planting and harvesting techniques including any special measures like crop rotation
   h) type of fertilisers used — farmyard (organic), or chemical (inorganic) irrigation practices
   i) marketing arrangements for produce.
4) Establish trends, following each crop from planting to marketing (e — i) in (3) above.
5) Compare these for the different crops, and arrange them in oder of their impact on the environment, from the least disruptive to the most. Give reasons for the ranking.
6) Suggest practical measures for alleviating the disruptive influences.
7) Arrange a non-formal educational seminar for the community for 25 participants presenting and discussing the findings.

Field trips

Environmental education places a high priority on field trips as a means of observing and experiencing the real life environment. It stresses the investigative skills of observing and measuring, the diagnostic and decision-making skills of analysing and synthesizing. It is a good method for building environmental awareness and for stimulating participation in community action.

The field trip also allows participation of each student by using the variety of abilities and talents present in the group.

The field trip can be organised to investigate any environment. It is flexible in that the focus of the visits can be varied to illustrate the various components of an environment and to build an understanding of interaction processes between the components. For example, a field trip arranged to study an uncultivated plot of land must examine the following:

i. distribution of the plants
ii. animals and their relationship to plants

iii. predator-prey relationships: food chains
iv. effect of man's presence
v. soil and climatic conditions on macro and micro scale; the effect of these

A field trip to a work place must study the following:

i. materials used in production
ii. processes of production
iii. human resources — sex, number
iv. working conditions — pay, hours, noise levels, sanitation
v. disposal of waste
vi. protection of consumers — quality control
vii. location of work place in relation to natural and social environments

Follow-up activities should stress the recognition of inter-relationships, trends, the prediction of patterns of development/growth, and of consequences for the particular environment as well as the environment in general. An environment studied over time should lead to an appreciation of the concept of dynamic equilibrium.

Field trips are, however, time consuming and may be expensive. To be successful, they also call for good organization, including the cooperation of enough teaching staff and/or parents/adults of the community to assist with supervision. Students also have to be very disciplined to minimize damage to the environment due to their activities, especially in areas which are continuously used by many people.

3–5.
Activity 3: Investigating a rocky seashore
Activity 4: Investigating a sandy seashore
Activity 5: Investigating an urban environment
Teaching/learning strategy: *Field Trip*
Skill group: A (Investigative)
Mental processes: planning, observing, measuring, analysing, inferring, recognising patterns

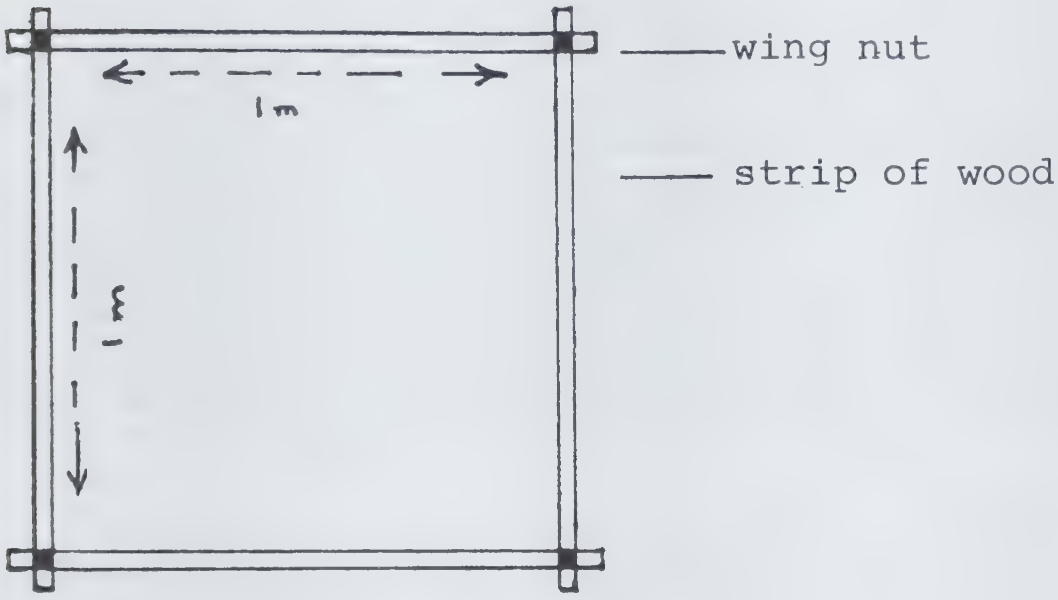
All of these activities will require a series of lessons. The basic steps in preparing and carrying them out will be similar, but details of observations, species, interactions will be different. Generalized guidelines for field trip activities are first presented. The specific objectives and some field tasks for each activity are then dealt with separately.

Generalized guidelines for field trip activities

1. In the classroom/laboratory
   Preparation for the trip.

a) Discuss the *content:* this is interpreted here as making decisions on the location to be visited, and what to look for. Stimulus materials in the form of pictures, films etc. should be provided for the students, since the teacher will have some previous knowledge of the sort of location to be investigated. In spite of this, decisions are to be joint, with input from both tutor and students. Out of this discussion should come a series of questions which students might seek to answer as a result of observations made on the field trip. Discussion should be within the framework/background of general factors pertaining to a whole area, e.g. climate.
b) Outline the *procedure* to be followed on the trip. Students will need to be constantly reminded of this, but should have from the outset some idea of how they will set about answering the questions isolated in (a).
c) Students should be introduced to any *tools* they might use. These might include a hand lens, thermometer, a metre rule, a simple quadrat, rope. Students might need to make their own

metre rules, using strips of wood. They should make their own quadrats. These are simple devices to facilitate counting of species, and can be made from string, wire or wood, depending on what is available. Usually, sizes are one metre square, and 25 cm square. Since these will need to be carried, the ease with which they can be taken from one place to another is important. For example, if a wooden frame is used, it might be held in place by four nuts, so that it is collapsible.



If a wood is to be investigated, then a larger quadrat, say five metre square will be needed. This is best made of rope, knotted, or better — marked with coloured material interwoven into the strands — at the required distances. In any event, a length of rope marked like this, is always useful for quick measurements of longer distance.

d) Instrumentions should be given on *how to collect specimens.* This is absolutely essential, as one danger of this kind of activity, especially if the location chosen is one that is heavily used, is that animals and plants are disturbed, and this could lead to their eventual loss from an area. It is in this exercise that there is an excellent opportunity for inculcating an attitude of caring for the environment. A general rule is that no plant or animal should be collected if it makes a significant change in the environment. The collection of a rare flower makes a significant change, but a spoonful of sand at a beach does not.

   Containers for specimens should be collected: as far as is possible these should be of unbreakable material. Jars should have screw caps. Plastic bags with suitable 'ties' are excellent for keeping plant material fresh for a day or two.

2. In the field.

It is absolutely essential that for any group of students taken on a field trip, consideration be given to their safety. For example, if the trip is to the sea or a pond, there should be a sufficiency of strong swimmers in the group. More than one tutor should accompany the group

a) At any chosen site, an intitial discussion should focus the attention of the class on the overall picture. This discussion should arise out of general class observations of outstanding characteristics of the site.
b) Groups should then be designated for specific tasks in the collection of data e.g.
   — for making physical counts of plants and animals
   — for looking for evidence of interrelationships, like food chains or nesting arrangements
   — for drawing a "map" of the site.

— for making temperature measurements of soil and air
— for collecting soil samples and determining soil pH
— for noting the effect of human impact.
Each group must have one person who records; without this, information tends either to be lost or to be inexact.

3. In the classroom/laboratory.
Follow-up work after the trip.
a) Living specimens should be sorted, and further examined and discussed.
b) Plants and animals should be classified and ecological modifications noted.
c) Soil should be examined for animal life, and experiment(s) done to determine some of its characteristics, for example, estimation of its humus content, or water holding capacity.

This phase of the work is one where students often need much guidance. The work, of necessity, involves detail, and the motivating excitement of the trip itself will have passed. Exercises should challenge the students; the whole purpose of this 'clarification' exercise is to enable them, through a closer look at the soil and living things in an area, to formulate some conclusions as to why the area studied carried the particular relationships which it seemed to support. Particular attention should be paid to evidence of environmental stress, and the reactions of living organisms to this.

4. In the classroom/laboratory

Preparation of a permanent report

This helps to improve students' communication skills, and to fix what they have seen in their minds. The record might include —

a. a written outline of steps in the investigation
b. charts and/or histograms to illustrate the relative numbers of species
c. pressed plant specimens and preserved animal specimens
d. drawings to illustrate interrelationships noticed
e. a map of the area, which need not be to scale. The important thing is for students to pinpoint the chief physical aspects of the site
f. an analysis of the effects of man's presence in the area

5. In the classroom/laboratory

A display of the material out of step 4 should be arranged. Other members of the college and general community might be invited, and class members given turns in explaining the exercise to their peers. This builds interest and confidence and the questions asked would generate ideas for future work.

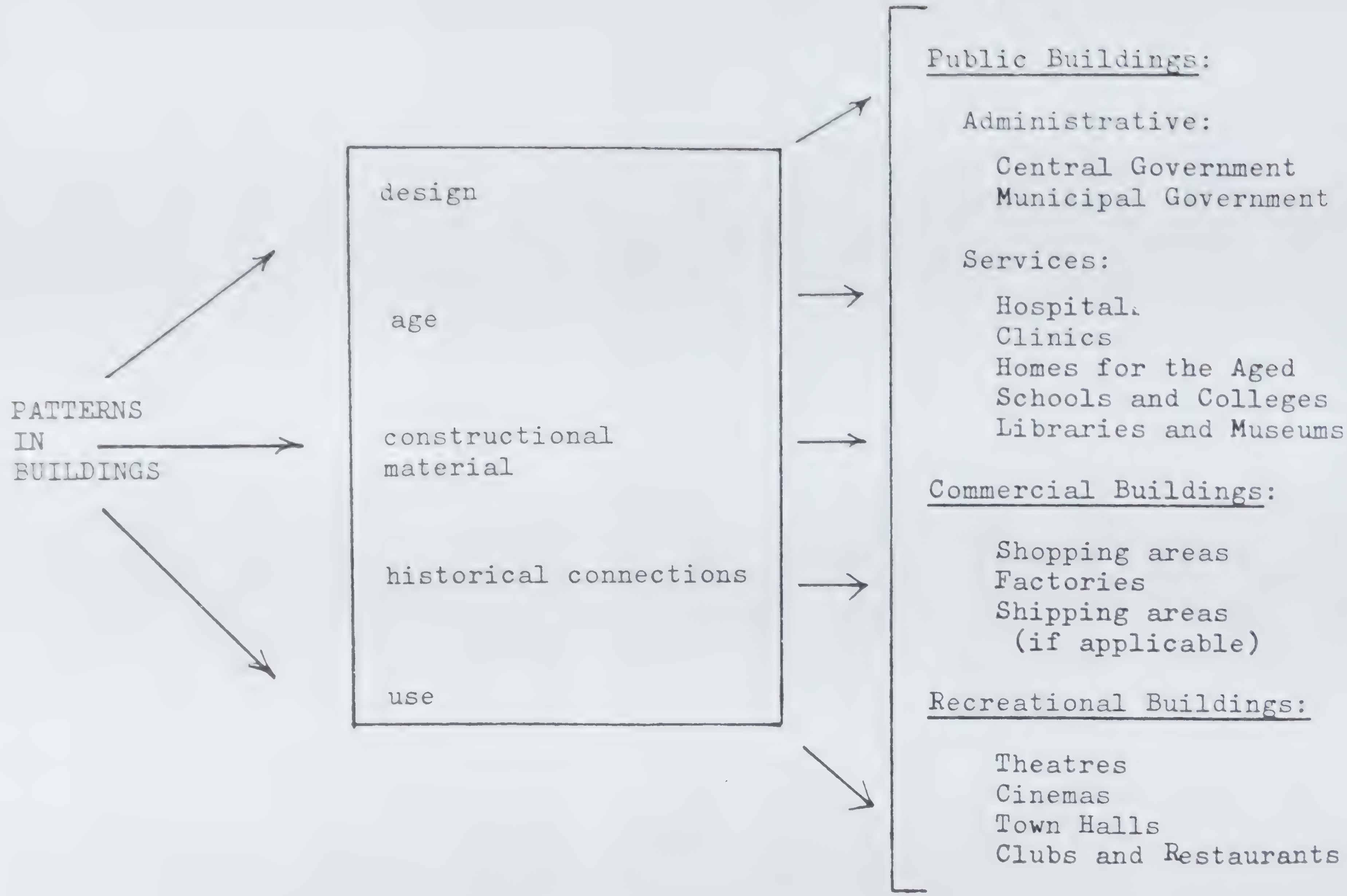
Variations of this type of activity include a comparison of two sites studied, or a long study of a plot which is near by, over a period of six months or a year, as might be feasible. This would allow for more emphasis on the isolation of patterns. The basic approach would be the same as outlined above. The longer study would allow for a community display, which would thus provide one way of increasing community understanding of the local environment.

Activity 3: Investigating a rocky seashore
Activity 4: Investigating a sandy seashore

Objectives

Knowledge: Students should be able to describe
— the types of plants and animals found in the environment on sandy shore and in shallow water clinging to rocks and under stones
— modifications of living organisms for survival in the environment e.g. succulence of plants, clinging 'foot' of chiton

Preparatory ideas for a unit on 'Patterns in Buildings'



— the micro-climate and soil of area under study
— the effect of man on the area
— any zoning or other patterns in evidence in the area.

Skills: Students should be able to
— measure temperatures of air, soil, water
— choose and collect necessary specimens without destroying their habitat
— draw a map of the area depicting main features.

Attitudes: Students should demonstrate
— care in the procurement of specimens
— respect for life
— willingness to make reasoned judgments based on evidence.

Rocky seashore environment. Field tasks.

General introductory: Students might note:

a) high and low tide marks
b) where the water 'breaks'
c) the abundance/scarcity of rock pools
d) evidence of wind action.

Specific group tasks:

a) Finding out and comparing animal types to be found in several rock pools. Types might include fish, molluscs (nerites), sea urchins.
b) Noting which animals are in areas never covered by the water; types include molluscs (winkles), hermit crabs (crustacean inhabiting a mollusc shell and therefore a good example of peculiar species relationships).
c) Finding out which animals are found where the water 'breaks'. Chiton might be one notable example found. This mollusc has an enormous capacity for holding on to rock.
d) Looking under coral rock in shallow water for animals: these might include brittle stars, Hermodice (annelid worm), sea urchins. Sea hares may be seen in the water too.

Sandy seashore environment. Field tasks.

General introductory: Students might note:

a) presence/absence of zones in the vegetation on the shore
b) outstanding characteristics of plants, e.g. presence/absence of thorns, succulence, erect or creeping growth form
c) presence/absence of mangrove swamps
d) high and low tide marks
e) evidence of wind action.

Specific group tasks:

a) Estimating the relative size of zones (if present) by measuring across them in two or three places.
b) Counting plants and animals in quadrats. The emphasis here should more be on general characteristics rather than on specific species identification although some measure of this is necessary. They could use characteristics such as thorniness, hairiness or succulence as distinguishing features for plants, and should be expected to recognize common animal types like insects, birds, spiders, as well as look out for unusual organisms.
c) Measuring air, soil and water temperature.
d) Looking for paths, garbage, fishing boats, or other evidence of human activity.
e) Looking for plants and animals in shallow water off shore. Plants might include Thalassia,

marine algae like Mermaid's Wine Glass, and washed up pieces of dead Sargassum. Animals might include sea anemones buried in the sand, schools of fish, barnacles near the water's edge on the roots of trees, or bits of coconut husks.

Activity 5: Investigating an urban environment.

The city provides a wealth of possibilities for investigation. For example, if one adopts the central theme 'Looking for Patterns', this could lead to several alternatives, such as those patterns in the:

— lay-out of roads
— design of parks and gardens
— design of buildings
— flow of traffic
— distribution of the commercial and residential sectors
— occurrence of traffic accidents
— placing of illuminated display signs
— situation of health services, e.g., hospitals, clinics.

The list is by no means exhaustive, but all can provide excellent opportunities for a consideration of the total environment. So much of the city ecosystem is man-made that a study of urban patterns should be instructive in showing to what degree these have been successfully superimposed on and interwoven with the natural environment. The main steps enunciated for other field trips still apply: there must be careful preparation, followed by the actual field work, the analysis and reporting of the findings. However, the variables affecting the situation may be at once so much more complex and more subtle in their effect, that a determination of the content to be explored necessitates a careful break-down of the possibilities which might be open for study.

The scheme below suggests one set of ideas which might be used in formulating a unit on buildings. The analysis immediately reveals that for a meaningful and successful activity, choices would have to be made. The construction of such a scheme should have input from teacher and students, and the final decisions should largely be the latter's.

The following are a set of specific objectives which might be considered for a unit on patterns in buildings in an urban environment based on the scheme outlined.

Knowledge: Students should be able to
- — describe the gross lay-out of the city, identify buildings used for administrative, service, commercial and recreative purposes
- — state the historical origins of a sample of each type

Skills: Students should demonstrate the ability to
- — classify buildings by size
- — identify patterns in the kind of building materials used
- — make choices between alternatives

Attitude: Students will begin to develop
- — an appreciation for the cultural pursuits and heritage of their community
- — an awareness of the beauty in buildings
- — a willingness to work in groups

Experiments

These give good practice in the use of all the mental skills listed. In particular, experiments offer the advantage of controlled situations in which a single process can be observed and the complexity appreciated. For purposes of environmental education experiments should focus on change resulting from external interference and from internal growth or change. The process by which an organism or environment responds to change and the ability to survive varying degrees of interference should be investigated.

Activity 6: To find out the effect of slope and ground cover on soil erosion patterns
Teaching/learning strategy: *Experiment*
Skill group: A (investigative)
Mental processes: observing, measuring, inferring

Objectives

Knowledge: Students should be able to state one way in which soil erosion may be prevented

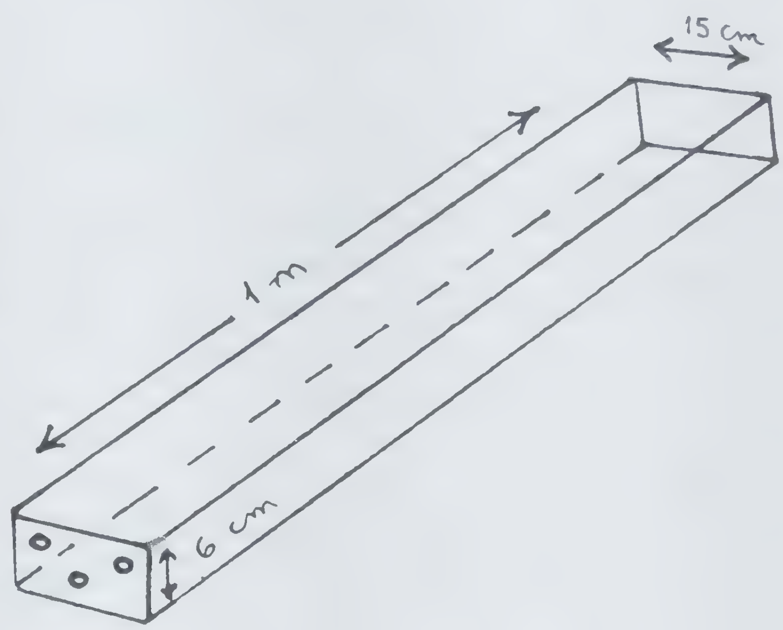
Skills: Students should demonstrate an ability to
- — follow instructions and carry out an experiment
- — read a measuring cylinder
- — observe and record findings in tabular form
- — write a short descriptive paragraph outlining a plan of action for correcting erosion in a specific area

Attitudes: Students should demonstrate a willingness to
- — find out things for themselves
- — wait patiently through the time a system may need to adjust
- — share their knowledge with members of the wider community

Outline of Procedure:

This activity might usefully be done by several groups simultaneously, to point out how the repetition of experimental results builds up trends in knowledge.

a) Set up six uncovered boxes of the same size and shape (1 m × 15 cm × 6 cm) with holes at one end for drainage.
b) Fill them with the same type of soil; plant three boxes with grass. Leave them for about a week to allow for adjustment.
c) Arrange the boxes in three pairs. Each pair has one with grass, and the other without. The first pair is tilted at an angle of 60°; the second at an angle of 30°; the third is kept horizontal.
d) Pour the same quantity of water from the same height on each box in turn. Use the same container.
e) Set up catchment for the water and soil which washes through. Measure the amount of each from each box.
f) Record the results in tabular form, as below.



	Experimental conditions	Vol. soil	Vol. water	Conclusions
Box 1 Box 2 Box 3	Tilted 60°; unplanted Tilted 60°; planted Tilted 30°; unplanted etc.			[answers to questions (i) to (iv) below.]

g) Answer the following questions based on the results you have obtained: —
(i) What would you say is the effect of slope on surface drainage?
(ii) What would you say is the effect of ground cover on surface drainage?
(iii) What would you say is the effect of slope on soil erosion?
(iv) What would you say is the effect of ground cover on soil erosion?
(v) Write a short paper outlining how you might help the inhabitants of a community you know where soil erosion is a problem, to correct of minimize the problem.

Activity 7: To find out the population growth patterns of yeats
Teaching/learning strategy: *Experiment*
Mental processes: observation, measurement, inference, hypothesising
Objectives
Knowledge: Students should be able to state
— how different growth patterns are represented in a graph
— the effect of warmth on the growth of yeast
— some of the principles of population growth
Skills: Students should demonstrate an ability to
— follow instructions to carry out a practical task
— measure volume accurately in cm^3
— use the microscope and haemocytometer
— record results in a graph

— draw conclusions from the graph
— use the research skills necessary to obtain population figures
— compare results from two situations

Attitudes: Students should be willing to
— find out things for themselves

Outline of Procedure:

a) Prepare a suspension of brewer's yeast.
b) Measure 50 cm^3 of two per cent sucrose solution into a 250 cm^3 conical flask.
c) Add one drop of the yeast suspension to this flask; plug with cotton wool, and leave in a warm cupboard.
d) Make counts of yeast cells at specified times twice per day for five days.*
e) Record the counts in a table as each is made.
f) Plot a graph of the results, with time on the horizontal axis and cell count (number of yeast cells per cubic centimetre) on the vertical axis.
g) What inferences can be made from the shape of the curve?
h) Describe one event which might have changed the shape of the curve. In what way would it be changed and why?
i) Obtain human population figures for your village/town/city/country (whichever is available) for the last hundred years. Plot a similar graph of time against population estimates, using these figures. How does the shape compare with that of the yeast population? Explain any similarities or differences which you observe.

Situation Analysis

Practice in analysis of situations enables the student to identify significant variables (values, opinions, objects) which are interacting to create a situation. It is a useful strategy for building awareness and understanding and for helping to decide effective participation.

The strategy utilizes all the mental processes and is particularly useful for encouraging the making of comparisons and establishing priorities.

Activity 8: To assess the impact of socio-cultural change in an area
Teaching/learning strategy: Situation Analysis
Skill group: A (investigative), B (values clarification), C (predicting), E (evaluating)
Mental processes: analysing, prioritising

Objectives

Knowledge: Students should be able to state
— the 'push' and 'pull' factors of migration

Skills: Student should be able to
— predict the effect of a specified change in patterns of agriculture in an area
— form judments as to which are desirable/undesirable environmentally, and lead to a 'good society'

Attitudes: Students should show a willingness to work together to clarify e.g. criteria for making comparisons

Procedure: Students are to read the following passage and answer the questions which follow.

Note. *Yeast cells may be counted under the microscope using a haemocytometer. This is a special slide with a ruled area in the centre 1 mm^2 in area, between two grooves which delimit the fluid. The ruled area is subdivided. Using the $\times 10$ objective and $\times 10$ eye piece of the microscope, count the cells in 5 subdivisions. The average of these figures would be used in plotting the graph.

Border is a rural town about twenty unpaved miles from the main road to the nearest urban industrialised centre, Midtown. Many young men and women have left Border and gone to live in Midtown where some of them have managed to get jobs in factories. Older folk left in Border busy themselves with mixed farming and rearing grandchildren left by young parents or sent to them from Midtown. Sometimes there is enough food to sell to passers by, but it has to be carried to the main road. Most of the food is, however, eaten at Border. There is a small grocery stocked with tinned fish, bread and other items used in Border, but not produced there. The shop also sells oil for the kerosene lamps.

For health care and schooling beyond the primary level, people must go to Midtown.

Some thought is now being given to development for Border and this is conceived as being the expansion of monocrop farming of peppers which grow very very well there. By placing a preserving factory in Border and producing year round crops, it is believed that the living standard of the people will rise, and that the drift to the urban area will be considerably reduced. Young people from Border may actually return to live there.

Questions:

1. Through research and discussion, identify the economic gains likely to accrue to the people of Border as a result of this development.
2. Identify other changes which are likely to occur in Border as a result of this development.
3. Assess the effect of these changes on the total environment. Select which changes the citizens should accept in order that Border will maintain a 'dynamic equilibrium'.

Activity 9: Alternatives search
Teaching/learning strategy: Situation Analysis
Skill group: Values clarification
Mental processes: analysing, comparing, prioritising

Objectives

Knowledge: Students should be able to state
— the requirement for a successful tourist trade
— some of the environmental benefits and hazards of drilling for oil offshore, including the economical issues

Skills: Students should to able to
— discuss their ideas freely in a group situation
— report findings orally
— compare findings and establish environmental priorities
— make reasoned judgments as to their feasibility

Attitudes: Students should show a willingness to
— work together in a group
— be tolerant of other people's ideas
— clarify their values through dialogue with their peers
— act on decisions taken
— assist the government in carrying out its task

The problem:

You are an inhabitant of a small tropical island. The soil is not good for agriculture, and so most food items have to be imported at considerable cost. Some inhabitants make a living out of fishing and supplying other seafood, but the bulk of the earnings in the island come from a vibrant tourist trade. Beautiful beaches protected by prolific coral reefs are the island's chief asset. The rich are hoteliers and businessmen.

Recently oil has been discovered off shore. The Government is in two minds as to whether to extract it or not.

Newspaper articles which could be used for analysis:

THIS WONDROUS WORLD

Mountains are being dissolved.

The effects of the tens-of-thousands of tons of sulphuric acid from the industrial areas of western Europe which annually, by precipitation, fall over Scandinavia, can now be seen in the mountains. The increasing amount of acids corrodes the granite and brings about the disintegration of the surfaces, much quicker and stronger than "normally". This has meant that some of the oldest works of art in Scandinavia — the 4-5,000-year-old rock engravings — pictures of people, animals and ships cut into the sides of the mountains — are threatened with destruction. Archaeologists and geologists are trying to find ways and means to protect the unique mementoes of the people of the past.

THIS WONDROUS WORLD

Do they commit suicide?

At one time porpoises were to be found in great numbers in the North Atlantic, North Sea and the coastal waters of the Baltic. In spite of preservation laws, their numbers are rapidly decreasing. Thousands are drowned when they get into fishermen's nets, but most of them die as a result of pollution of the sea. No animal has a greater concentration of DDT and mercury in it than the porpoise. In pain, and weakened by poisoning, and terrified by the many new sounds in the water from the screws of ships, echo sounders and speedboats, they pile up on the beaches. It is not improbable that this is a form of suicide.

— Presse-Illustrations-Bureau

THIS WONDROUS WORLD

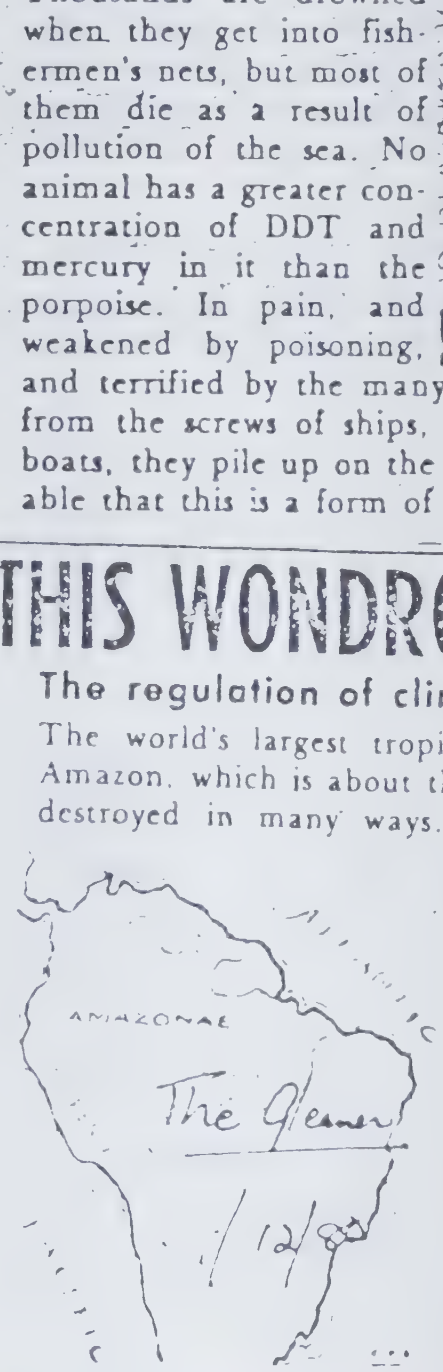
SOLAR ENERGY

A daring American experiment in the utilization of the sun's energy is to send a satellite solar power station into orbit at a height of 36,000 kilometres, where the sun shines twenty-four hours a day. The station will have two surfaces of solar cells, each of 25 square kilometres. They transform the sun's energy direct to electricity, which induces micro-wave generators mounted in a sender antenna in the centre (a kilometre in diameter). From here the micro-waves are sent to a receiver antenna on the earth (seven kilometres in diameter), where the energy from the micro-waves are again transformed into electricity. If this experiment is successful its capacity will be up to 20,000 megawatts — the present atom power station's productive capacity is about 3,000 megawatts.

THIS WONDROUS WORLD

The regulation of climate is destroyed.

The world's largest tropical rain forest area, the Amazon, which is about the size of Europe, is being destroyed in many ways. In connection with the building of the 6,000 kilometre-long motorway from the Atlantic to Peru, a forest area about the size of Great Britain is being felled. In other places they are burning off huge areas for the layout of rubber and coffee plantations. The same tendency is in force in the jungles of Africa and South-East Asia.



But the rain forests have always been a vital factor in the formation of oxygen and the regulation of a stable temperature here on earth. If this balance is disturbed so that the content of carbon dioxide in the air is increased, it will cause a change in the rise in temperature ... with

Questions:
What would you advise the government to do? Why?
What actions would you take to ensure that your advice is followed?

The class might discuss this as a group activity, with groups reporting to the class at the end of a timed discussion period. The various suggestions made by the groups should be assessed by the class as a whole. Criteria for evaluation might include —

— efficiency of proposal for protection of the environment
— ease of execution
— financial feasibility
— social repercussions in terms of employment opportunities and living amenities for man.

Activity 10: Analysis of newspaper report on environmental problems
Teaching/learning strategy: Situation Analysis, Discussion
Skill group: diagnostic, decision-making, values clarification
Mental processes: analysis, synthesis, prioritizing
Objectives
Knowledge: Students should be able to state the principles/bases of the environmental problem being studied
Skills: Students should demonstrate an ability to
— discuss a newspaper article critically
— make choices between alternatives
— predict consequences of problems prescribed if they remain unsolved
Attitudes: Students should show
— a concern for living things and the total environment
— an awareness of environmental problems
— a willingness to work in a group
Outline of Procedure

Students might be presented with reports or articles from local newspapers, such as those attached for analysis. A series of instructions which might be given them follows:

a) Read each article. For each define the environmental problem(s) which is/are the focus.
b) What might the consequence be if the problems are not addressed?
c) Discuss critically any solutions offered in the articles.
d) If no solutions are implicit, consider the possibilities, giving reasons.

For a more meaningful analysis, this exercise should be arranged as a group activity, with one group assigned one article. Group reports after a stipulated work period should stimulate a useful class discussion.

c) *Role-playing, simulation, debates, discussion*

Environmental education has, as one of its principal aims, the formation of attitudes. These four strategies are considered effective in fostering attitude formation and, where indicated, attitude change. In order to do this, they all require a classroom atmosphere/climate in which free and frank expression can take place between the members of the (usually) peer group and their teachers. Once again, the focus or selection of the activities will determine their usefulness in environmental education. Caring, a sense of balance, a willingness to action, a commitment to life-sustaining rather than life-destroying thought and action, a sense of relatedness, are the aims.

Activity 11: To explore the effect of man's introduction of a predator into an ecosystem
Teaching/learning strategy: role playing
Skill group: diagnostic Mental processes: analysing, synthesising, decision-making

Objectives:

Knowledge: Students should be able to state the dynamics of the relation between predator and prey

Skills: Students should be able to
— identify the consequence of the introduction of a predator into the food chain
— recognize the complexity of changes which might result from the introduction

Attitudes: Students should demonstrate a willingness to
— clarify values through discussion with others
— recognize the rights of others

Procedure: Study the following situation. Identify all roles and select players for each role. Players must then negotiate an agreement which will produce harmony in the environment.

> *The situation:* The Mongoose was introduced into Jamaica to control the Yellow Snake. Once the snake population had been reduced, the Mongoose lost its natural prey and had to find a substitute. It turned to Eggs and Chickens. This was a source of distress both to Fowls and to Man who owned them. A decision was therefore taken that there should be a meeting of representatives of all three communities and that some arrangement be negotiated in the best interests of all concerned. The arbitrator for the meeting(s) is Turtle, who has for many years studied the Ways and Habits of Land Creatures. The scene opens just as the chief representative of the Mongoose Community is explaining why eggs and chickens are needed by his community...

Activity 12: Making a values grid
Teaching/learning strategy: Discussion
Skill Group: Values clarification
Mental processes: analysing, comparing, prioritizing
Objectives

Knowledge: Students should be able to recognize topical environmental problems

Skills: Students should be able to weigh issues and make reasoned decisions

Attitudes: Students should show a willingness to
— accept another's viewpoint with tolerance
— keep abreast of 'environmental news'
— examine their own positions with regard to important issues
— take committed action to improve an environmental situation

Outline of Procedure:

Various questions of topical interest concerning the environment which have perhaps been discussed in the media might be used to encourage students to clarify their own positions with regard to these questions. This they could do by making a values grid. A tick would be placed in each of the seven columns below, as it applies to the particular issues.

The seven numbers in the columns represent the following seven questions:

i) Are you *proud* of your position
ii) Have you *publicly* affirmed your position?
iii) Have you chosen your position from *alternatives?*
iv) Have you chosen your position after *thoughtful consideration* of the arguments for and against it, and the consequences?
v) Have you chosen your position *freely?*
vi) Have you *acted on* or done anything about your beliefs?
vii) Have you acted with repetition, *consistency* or pattern on this issue?

The Grid.

Issues	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vi
1. 2. 3. etc.							

Students might work individually initially, then discuss their 'claims' in small groups. The aim is not to prove anyone right or wrong, but to clarify students' thinking on the particular issues. One useful application of this exercise would be to carry it out before students are exposed to environmental education, and to repeat it after the courses. One would hope for increasing levels of commitment to action in favour of the environment.

Issues might include —

— the proposed closing of a factory because of high levels of lead or other toxic material in waste

— the reclaiming of coastal swamp land to build cottages or hotels

— the proposed construction of a totally air-conditioned and carpeted primary school in a tropical island.

Activity 13: To clarify an environmental issue
Teaching/learning strategy: Debate
Skill Group: Values clarification
Objectives
Knowledge: Students should be able to recognize the biological, physical, sociocultural impact of different levels of technology
Skills: Students should be able to
— make a considered choice between alternatives on the basis of evidence presented
— defend their own point of view in argument
Attitude: Students should show a willingness to
— tolerate the views of others
— examine their own positions with regard to specific issues in public

UTOPIAN CHARACTERISTICS OF SOFT (ALTERNATIVE) TECHNOLOGY

Hard technology society	Soft technology society
1. ecologically unsound	ecologically sound
2. large energy input	small energy input
3. high pollution rate	low pollution rate
4. 'one way' use of materials and energy	reversible materials and renewable energy sources only
5. functional for limited time only	functional for all time
6. mass production	craft industry
7. high specialisation	low specialisation
8. nuclear family	communal units
9. city emphasis	village emphasis

The ideas of using a grid, and the seven questions quoted above are taken from Simon, Howe and Kirschenbaum, 1976, pp. 35–36.

Hard technology society	Soft technology society
10. consensus politics	democratic politics
11. technical boundaries set by wealth	technical boundaries set by nature
12. alienation from nature	integration with nature
13. world-wide trade	local bartering
14. destructive of local culture	compatible with local culture
15. technology liable to misuse	safeguards against misuse
16. highly destructive of other species	dependent on well-being of other species
17. innovation regulated by profit and war	innovation regulated by need
18. growth-oriented economy	steady state economy
19. capital intensive	labour intensive
20. centralist	decentralist
21. alienates young and old	integrates young and old
22. general efficiency increases with size	general efficiency increases with smallness
23. operating modes too complicated for general comprehension	operating modes understandable by all
24. technological accidents frequent and serious	technological accidents few and unimportant
25. single solutions to technical and social problems	diverse solutions to technical and social problems
26. agricultural emphasis on monoculture	agricultural emphasis on diversity
27. quantity criteria highly valued	quality criteria highly valued
28. work undertaken primarily for income	work undertaken primarily for satisfaction
29. food production by specialised industry	food production shared by all
30. science and technology alienated from culture	science and technology integrated with culture
31. small units totally dependent on others	small units self-sufficient
32. science and technology performed by specialist élites	science and technology performed by all
33. science and technology divorced from other forms of knowledge	science and technology integrated with other forms of knowledge
34. strong work/leisure distinction	weak or non-existent work/leisure distinction
35. high unemployment	(concept not valid)
36. technical goals valid for only a small proportion of globe for a finite time	technical goals valid 'for all men for all time'

[1] Quoted in Dixon (1973, p. 202–203).

Procedure: A debate around the moot

A society which adopts the principles of 'soft' technology undoubtedly offers the best for the total environment.

Robin Clark has suggested that the following differences would exist between societies which follow the 'hard' and 'soft' technology paths. Students might use these as a starting point to prepare for the debate.

Points made for and against the moot should stimulate out of class discussion by students and their friends, leading them to further clarification of their personal views on the topic.

f) *Games and puzzles*

Most students like to play games and there are some which require analysis and use of anticipatory and predictive skills in the sense that the possible reactions of other players must be considered before a move is made. Examples of these are dominoes, draughts, chess, chinese chequers. Students should be made aware of the mental skills involved and encouraged to exercise these very consciously in playing the games.

The creation of games is challenging, and students should be engaged in this activity i.e. creating games related to the environment which will develop mental skills as well as aid awareness

and understanding. These could vary in their demands on the players, ranging from word puzzles to games of the monopoly type.

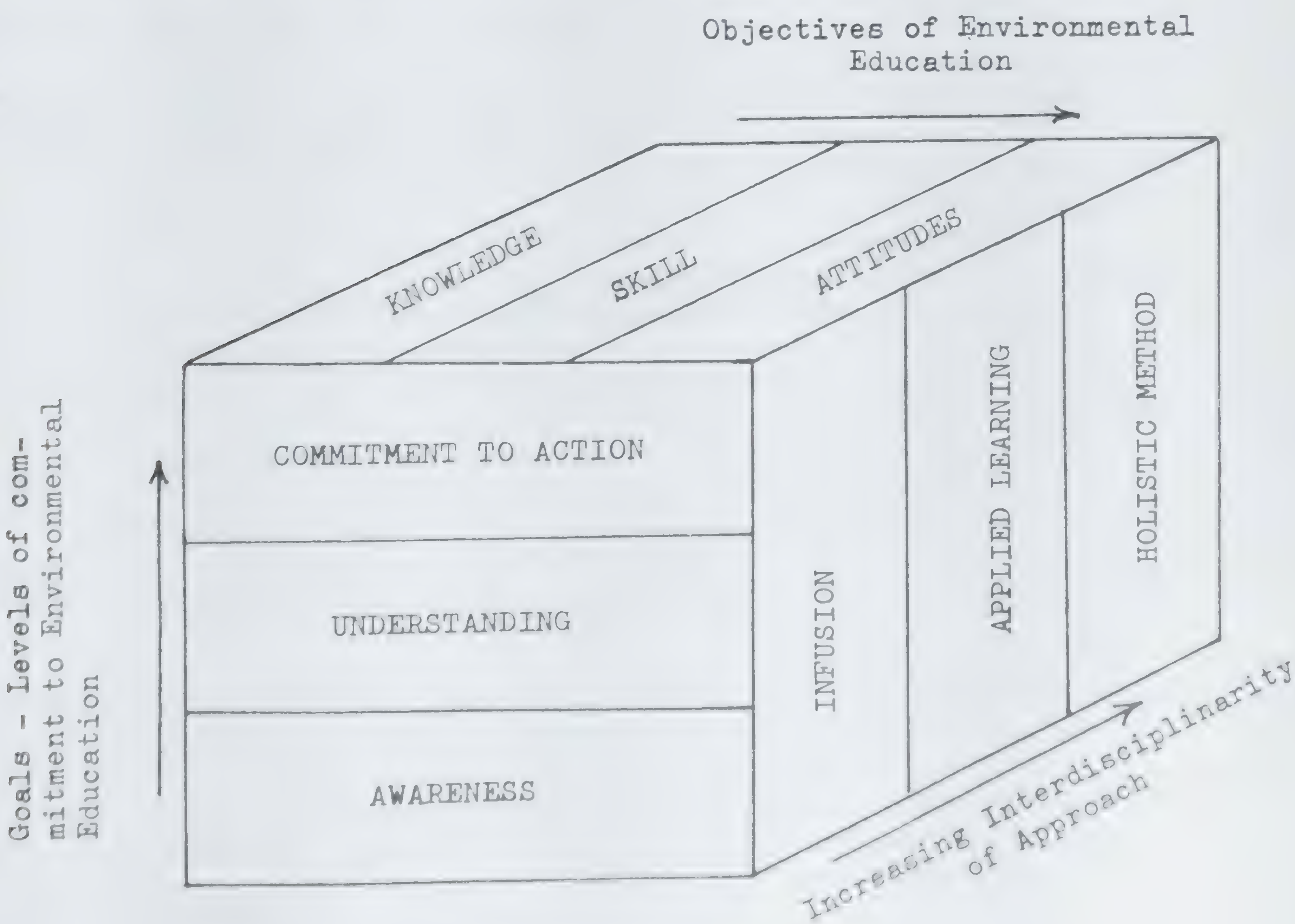
g) *Hobbies*

To familiarise students with their environment, the following activities are strongly recommended:

Animal watching — i.e. watching of birds, moths, butterflies, lizards etc. The object of watching is important; it must be to discover the life style of the creature, its response to its environment, to man, to others of its kind, to its friends and enemies. The study should reveal some beauty in the creature and help students develop positive attitudes towards it. These could be expressed by setting up feeding stations for them and developing a friendly link. Observations could be confirmed by reference to various texts. New information should be shared.

Star gazing — The rest of the universe is, more often than not, taken for granted. It was, however, through observation of the movement of stars and planets that priests and scholars of older civilization developed calendars and traced significant behaviours of the rest of the universe. The moon is considered to be associated with the movement of tides and the growth of crops; these relationships could be investigated.

The discussion so far dealt separately with the overall goals of environmental education, its objectives for the training of teachers, and the method to be used for achieving these. Figure 30 below illustrates how these considerations constitute a whole.



CHAPTER 7

Evaluation in environmental education

Tyler (1949) defines evaluation as the process of determining the extent to which the educational objectives are being realized by any programme of curriculum instruction. He goes on to point out that since the educational objectives aim at producing selected desirable changes in the behaviour pattern of the learner, then evaluation is really the process for determining the degree to which these changes are taking place.

It follows that the process must involve the collection of information on those behavioural changes, which must be both formal and systematic. The important use to which evaluative data should be put makes it imperative that this should be so. The data provide a basis on which to

— examine the effectiveness of learning experiences for producing the desired outcomes in learners
— assess variations in learner achievement
— estimate the effectiveness of the teacher
— identify strengths and weaknesses of learners and teachers and probably underlying reasons for them

The above implies that evaluation cannot be a 'one-shot' exercise; that any scheme for evaluation should involve both formative and summative aspects. Evaluation should be continuous throughout the programme of instruction (formative) and should also be carried out at its close (summative).

Evaluation must measure knowledge, skills and attitudes which pertain to environmental education. These have already been stated.

The usual instruments for assessing knowledge (questions—written and oral, practical tasks) are also suitable for environmental education. In addition, any of the teaching/learning strategies outlined can provide situations for assessing specific behavioural changes. It should be remembered that in practice only a single behaviour can be assessed in any one student at one time.

Practical tasks and objective-type questions are efficient ways of assessing the mastery of skills. Certain intellectual and communication skills, however, are best assessed by the use of essay-type questions and simulated situations, e.g. for decision-making. Research skills, skills of interviewing and debating clearly demand continuous, formative evaluation. Check lists for observation of desired behaviours are valuable tools for this purpose: suggestions for such a list follow.

CHECKLIST OF BEHAVIOURS WHICH MIGHT ACT AS INDICATORS OF AN ATTITUDE OF CONCERN FOR THE ENVIRONMENT

N.B. In checking these behaviours, the teacher must be sure to record *voluntary* behaviours. Some of these may be evident in the classroom, but observation outside the classroom and in the community must also be included.

LEARNING	PRIMARY LEVEL	SECONDARY LEVEL	TERTIARY LEVEL
Awareness	observes for example weather changes; seasons; plant and animal growth; phenomena associated with day and night; relationship, between natural occurrences and living organisms e.g. rain and plants	observes as Primary level, but with use of available instruments	
	uses the environment in creative work such as drawing, painting, poetry, stories, dancing, drama		
	acts, as far as possible, harmoniously with groups of which he/she is a member		
	recognizes the needs of others and gives or obtains assistance		
Understanding	asks questions of more informed persons in order to gain understanding		
		carries out self-initiated research in order to gain information/understanding	
	makes hypotheses about the nature of the environment, cause and effect in it; and tests them by means of questioning	makes hypotheses and tests them by experimentation, questioning, collecting data through reading	
		makes critical judgments including the welfare of the environment as a criterion of what is valuable/desirable	
Action	assists in care of living organisms	joins and/or organises activities to learn more about the environment through e.g. star-gazing, bird watching, 4-H clubs, cultural clubs	
	keeps environment free of garbage/waste		
		takes part in/organises community-oriented club activities including those dealing with the social environment e.g. Key clubs	
	shares learnings about the environment with family and friends		
	encourages others to be concerned for the environment		
			takes part in decision-making processes at local and national levels and promotes concern for the environment
	makes personal choices which reflect a definite consideration for the good of the total environment		

As has been shown, the major goal of environmental education is *attitude change*. Unfortunately it is very difficult to evaluate attitudes. Check lists of behaviours which are indicators of attitudes are a means of assessment as also are role-playing and simulation exercises. Two problems arise — how permanent is the attitude change? and how deep is the commitment?

On the question of permanence of change, there is little chance to ascertain this during the period of training. Concerning the level of commitment, the ultimate goal is *action* which the teacher-in-training may or may not attain within the training period. Both problems can be

addressed through planned in-service follow-up.

It cannot be emphasised too strongly that the teacher-at-work must be a community leader in environmental education and environmental action and that, consequently, every effort must be made to help each of them to achieve the highest level of commitment.

The critical area of planning for evaluation in environmental education is the statement of objectives. Classroom objectives must be very specific, very clear and measurable. For example, one broad objective of environmental education is 'to develop in individuals an awareness of the total environment'.

One unit of instruction in this programme designed to speak to that general objective and labelled 'The Nature of the Environment' may consider the following as objectives:

To help students to

1. realize that the total environment encompasses natural, social and cultural elements
2. understand that these elements are interdependent and continuously interacting
3. be conscious of the fact that they themselves are an integral part of the environment

For a single lesson within this unit on say "The social elements in my school environment" then specific, measurable objectives might read as follows:

Students should be able to

— identify the social groups in the school environment

— give examples of their interaction

— assess the impact on the total school environment of one type of group interaction

In stating objectives for teacher training, it is necessary to include professional objectives. Suggestions for these have been made by Wilke in "Strategies for the Training of Teachers in Environmental Education: A Discussion Guide for UNESCO Training Workshops in Environmental Education", 1980. The following are selected from this list:

The primary level teacher should have competency to

1. select effective instructional methodologies which are appropriate for desired cognitive and affective outcomes, receiver characteristics and available facilities (e.g. time, money, personnel)
2. effectively implement the following methodologies to achieve environmental education goals:
   A. outdoor education methods
   B. affective education methods (e.g. values clarification)
   C. simulation games (including role playing)
   D. case study methods
   E. community resource use (ecological, issue related, human resource)
   F. methods of autonomous student and/or group investigation, evaluation and action planning for resolving environmental issues
   G. appropriate teacher behaviours while handling controversial environmental issues
3. develop and use effective means of planning for instruction
4. effectively infuse appropriate environmental education curricula and methods into all disciplines to which the teacher is assigned
5. effectively evaluate environmental education curricula and methods achievement with receivers in both cognitive and affective domains.

A measure of teacher effectiveness is an essential component of this comprehensive evaluation exercise. As with any other branch of educational assessment, change over time is important. It is, therefore, useful to have a rating scale for recording the teacher's level on several different aspects at different points of training. The outline provided gives one format which could be used for this.

Profile of performance levels on criteria related to teacher behaviour for environmental education

	1	2	3	4	5
A. *Planning a lesson*					
1. OBJECTIVES — clear, precise, significant					
2. CONTENT — of good quality, appropriate					
3. LEARNING ACTIVITIES — appropriate to objectives, well sequenced					
4. SCOPE — place within the course as a whole					
B. *Implementing a lesson*					
1. ORIENTATION — focussing interest, establishing readiness to learn					
2. MANAGEMENT — timing and variety of activities					
— pace of the lesson					
— use of physical space, indoor or outdoor					
— use of audiovisual aids and equipment					
— use of the environment directly					
3. COMMUNICATION — quality of oral communication					
— quality of written/graphic communication					
— response to non-verbal cues					
— ability to frame clear, provocative questions					
— ability to give clear, precise instructions					
4. RELATIONSHIPS — sensitivity in detecting and responding to learner needs					
— empathy with learners					
— encouragement and use of learner suggestions					
5. EVALUATION — strategy used for assessing achievement of objectives					
— awareness of learner difficulties					
C. *Teacher's self-evaluation*					
— teacher's evaluation of lesson outcome and suggestions for improvement					
— teacher's evaluation of his own techniques					

In summary the evaluative process should be recognised as an integral part of curriculum planning and development, not as an afterthought. Where, as with environmental education, traditional curriculum material has been reorganized, the feedback evaluation provides is doubly important for the clarification and refinement of courses. At the more immediate level of the teaching/learning situation, evaluation serves to give both teacher and learner information on the learner's progress. It also helps to motivate the learner, and allows for an objective appraisal of teacher effectiveness.

Instruments developed for the exercise, whatever their particular purpose, should be valid, that is, they should measure what they purport to measure. They should also be realiable; they should not yield wildly fluctuating results from the same occasion. That is, two observers looking at the same situation and evaluating it on the same criteria, should register similar ratings. Lastly, evaluation exercises should be as objective as possible. It is difficult to eliminate subjectivity, especially where attitudinal traits have to be assessed. Much can be achieved in this direc-

tion, however, by structuring instruments to record specific behaviours. Questions on content-based tests should have particular functions, and observations of teaching/learning situations should be based on previously determined criteria of teacher or learner behaviour. It should also be remembered that forms of evaluation should be acceptable to those being evaluated, whether or not they are conscious of the process. Unless this is so, individuals will not function normally or spontaneously in a situation, and the exercise will not yield useful results.

CHAPTER 8

Management of environmental education in the primary classroom

This chapter is directly concerned with the *teacher at work* in the primary classroom. It shows how the knowledge about environmental education must be selected, adapted and modified for the primary-level student and how it can be included in the curriculum. Because the primary-level teacher is usually a generalist — a teacher of many, if not all, of the subjects taught at that level — the primary school teacher has greater control over the curriculum than specialist teachers at the secondary and tertiary levels. The infusion method seems an obvious choice for teaching at this level. The holistic method is not recommended. The goals of the teaching should be concerned mainly with attitude formation through awareness, appreciation and action. There will, inevitably, be the inclusion of factual knowledge and the development of appropriate skills, but since most of these are not peculiar to environmental education, the main contribution to environmental education will be attitudinal.

The child, at the primary level, should develop a sense of his own position in the total environment and be aware of the effect of the environment on him and of the effect of his own actions on the environment. At the end of primary schooling, the child should have reached a basic level of what might be called 'environmental literacy'. This implies the acquisition of learning fundamental to further learning at the secondary and tertiary levels and an ability to apply this learning in making decisions. Just as the child can apply reading skills to reading new materials, and apply computation skills to everyday problems, so the learning of environmental education will be applied in daily living. The problem of daily living which a primary school child may encounter may include drought and/or floods resulting in the loss of crops, animals, houses, epidemics due to polluted water. These are some of the problems to which learning must be applied.

The 'environmentally literate' person has acquired a life style which is environmentally appropriate in the sense that this life style allows the environment to function as a life support system in the total ecosystem. The teachers must accept that this life style may well be different from that currently practised by the adults in the society, and understand that teachers will be actively involved in changing their own life style as they and their pupils learn how.

The management of environmental education includes the familiar processes of planning, developing and implementation, evaluation; these are, therefore, the functions which the primary level teacher must perform individually or more desirably with a team of colleagues.

Planning

The planning process begins with the formulation of objectives; that is, the teachers in a particular school must decide what specific knowledge (facts, concepts), what problem-solving skills, what attitudes and what opportunities for applied learning will be included in the primary curriculum.

Next this learning must be distributed through the different grade levels.

Since environmental education is regarded as an added dimension/goal for the school's curriculum and not as a new subject, the next step in planning is to examine the existing curriculum of the chool to determine whether a suitable base is there for the development of environmental education. If this is not so, then a base must be written in. Where the teaching is single subject teaching, this will mean the addition of new topics; where the teaching is integrated teaching, it will mean the addition of new themes. Once the teachers are satisfied that the base is in place, they must select appropriate teaching/learning strategies. In order to satisfy the objectives of environmental education, these must be child centred and activity oriented.

Objectives for environmental education at the primary level

One possible formulation follows:

(i) To have pupils achieve a simple, factual awareness of their environment in general terms and of their place in it;

(ii) To arouse in pupils an understanding of, and interest and healthy curiosity in their environment, and to utilize this understanding toward satisfying their natural curiosity in part;

(iii) To lay the foundation for the development of positive attitudes in pupils towards their environment;

(iv) To develop in pupils a willingness to work individually and in groups in cooperation with others to effect the maintenance and preservation of the environment;

(v) To develop skills for learning about their environment e.g. skills of observation, collection, classification.

Objectives (i) and (ii) are knowledge goals, (i) being at the level of facts and concepts and (ii) being at the slightly higher level of comprehension. In addition, objective (ii) includes a motivational element. Objective (iii) states an attitude objective. Objectives (iv) and (v) state goals for social growth and name some mental skills. These are general objectives, goals, and must be transformed into more specific terms for classroom instruction.

Knowledge

To spell out the knowledge objectives, it is helpful to ask the following question:

What are the specific facts and understandings each primary school child should have about the environment and his/her place in it?

The child must know the animals and crops which grow in the area, about the soils and rocks, about the sun, moon and stars which he sees every day. He must know where the water sources are, where the gases he breathes come from, what provides the temperatures experienced and how they are changed or maintained. He must understand the ways in which the environment creates comfort and discomfort for all and how all of us cause comfort and discomfort to other organisms including those elements we call non-living. The child must understand that he is both a taker and a giver in the environment.

Skills

Both social and mental skills are included in the goals of environmental education. The mental skills named in objective (v) are essential for building environmental awareness. But since the

activities at primary level will include both problem solving and environmental action, the problem solving skills (collecting information, recording it, using it to solve problems by proposing alternatives, evaluating them and selecting the most suitable), and the skills of planning and organizing group action must also be included.

Attitudes

Environmental education is education directed at relationships between man and the physical environment and between man and all other men of the planet. The aim must therefore be to foster all those attitudes which will make for good relationships and for increasing the knowledge base for understanding and decision-making. The list therefore includes: care for the physical environment, curiosity, a desire to investigate, creativity, friendliness, respect for all other humans of own community, nation, planet.

Development and implementation

Planning for environmental education will reveal the need for lesson plans or for modification of existing lesson and unit plans, for resources and aids to support the teaching. The greatest and most available resource is the environment itself with its visible population of flora, fauna, people, soils and rocks, mountains and rivers. It is about these that information must be gathered and towards which positive attitudes must be built. The teacher should, therefore, identify all the components of the local environment and decide the ways in which they can best be used to further the goals of environmental education.

Books, films, filmstrips, pictures, games, puzzles are helpful aids; the teacher will, more likely than not, have to create games and puzzles to teach environmental learnings. A collection of stories, poems, plays about the environment and environmental relations, about people and their relationships, will form a valuable stock-in-trade for the teacher of primary school children.

Lesson planning

Some amount of lesson planning will be needed to translate plans into classroom action. Where new topics are added, new lessons may have to be planned. In general, however, since environmental education is regarded as an added focus and not as a new subject, it is envisaged that modification of existing units and lessons may be all that will be necessary in the main subject areas of the primary school curriculum — reading, writing, arithmetic, art and craft, social studies, physical education. The modifications may be of three kinds:

1. addition of environmental learnings about a topic
2. additions of attitude objectives of environmental education
3. change of learning activities to ones which are more child centred and action-oriented.

Teaching/learning strategies

'Child-centred, action-oriented learning' means that the child is made responsible for his/her own learning in that learning is brought about by activities performed by the child rather than by activity performed by the teacher mainly. Instead of teacher as the teller and doer (e.g. of experi-

ments) the child is the main actor who investigates, discovers, questions, experiments and learns in this way. This is not to say that the teacher has nothing to do; the teacher still remains the leader, the guide, the grown-up partner in this new dimension of learning. The teacher must create the classroom climate in which the child is stimulated and freed to use his mental powers. As far as possible, the teacher must provide opportunities for the observation of the environment outside the classroom through field trips with well defined objectives. These may take the form of trips with the children to a river, field, factory, for example, to make observations and gain understanding of life activities there. Role-playing will allow the exercise of creative skills and deepen understanding of others in the environment. Problem solving exercises, guided class discussions are also strategies which the teacher may use. At this level, story telling with dramatization will aid attitude formation and add enjoyment to the classroom.

Development of the skill of questioning by the teacher will focus the thougts of the children on environmental concerns. For example, the everyday activity of washing clothes relies on the action of the sun and the wind for completion. This is, however, taken for granted by everyone. The four questions which follow would be making use of this ordinary event to teach environmental relationships and appreciation:

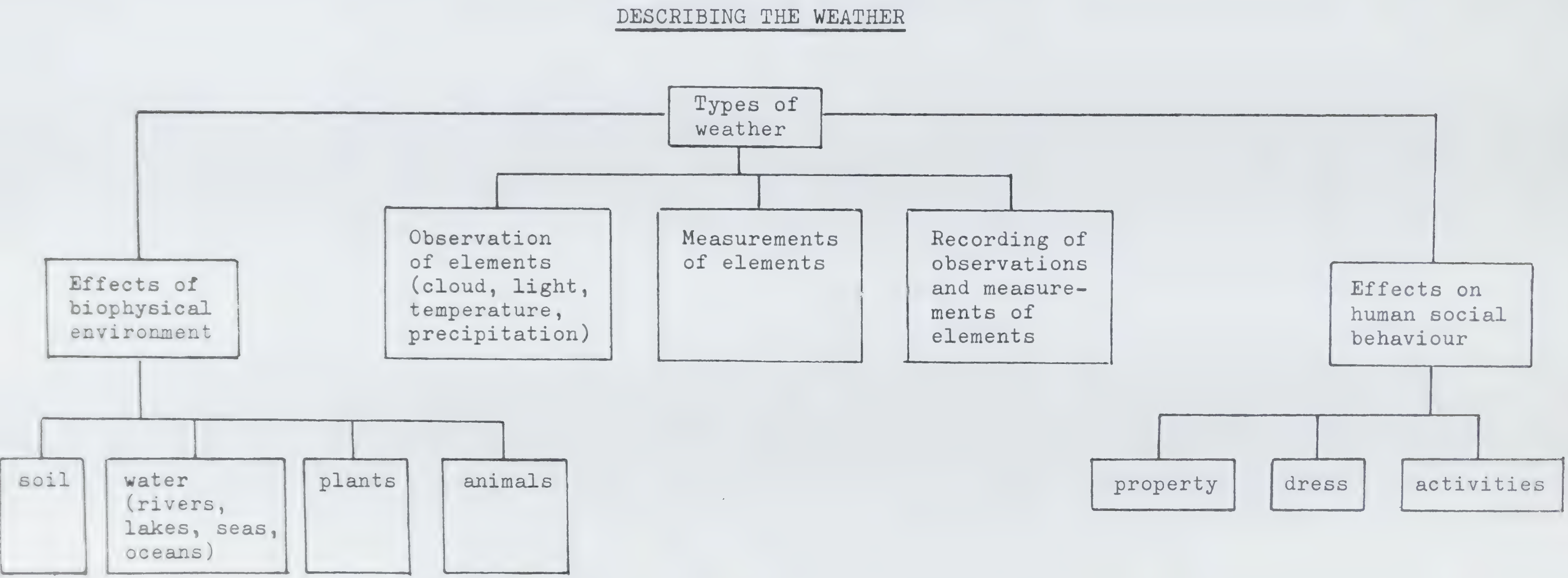
1. What would happen if it started to rain just when it was time to put the washing out to dry?
2. How would you feel if the rain fell for such a long time that the clothes you wanted to wear to school (party, church) were so wet that you could not wear them?
3. Who, in your community, might be glad for all that rain? Why?
4. What really happens to all the water in the clothes?

Questioning of this type may be all the modification that is needed to make a lesson into a significant addition to environmental education.

Evaluation

Evaluation of the effectiveness of teaching about the environment will be reflected in the child's increasing awareness and interest in the environment. While written or oral questions may show increasing knowledge (facts gained, concepts acquired), the teacher must re y heavily on observation of the child to assess this growth. Expressions of awareness and interest at the grade one level will differ from those at the grade six level. What the actual signs or behaviours are, must be charted by the team of teachers in the school and a record should be kept for each child ever the six years of primary schooling.

VARIOUS ELEMENTS THAT COULD BE USED IN A LESSON ON WEATHER



Modified from: Final Report,

Subregional Training Workshop on Environmental
Education for the Caribbean Unesco 1980
p. 25

Conclusion

Crises of war, food shortages, floods and other natural disasters, population growth, inflation, among other things, have forced technological man to take a critical look at his life style.

Countries are labelled 'developed' and 'developing' on the basis of their industrialisation level and wealth — on the basis of what they own. But what **is** development? The term is to some extent a cultural one. Much can be done by the poorer nations to cultivate a way of life which would avoid many of the environmental problems consequent to heavy industrialisation. In other words, they must define and actualize a new concept of development/progress.

Whether, however, one is a part of a developed or developing nation, it is essential to be able to recognise the environmental problems which exist, and to make decisions for action in order to deal with them. The world has to be considered globally in this context, and it is in the light of this that environmental education for all becomes, not just a desirable, but a *required* goal for all political and educational systems.

The difficulty is in achieving the goal, for environmental education is aimed at changing an *attitude* in man, from one of the exploitation of the environment to one of acting in tune with and enhancing the environment. Attitude change is a personal thing. Each individual has to be responsible in the final analysis for his own change.

Teachers have to make a conscious effort to change their own attitudes before they can hope to direct the children they teach toward a desirable commitment to the environment. The task of instilling in the next generation of adults a concern for the environment is largely in their hands, and the importance of their training for the task cannot be overstressed.

This module has attempted to provide some aspects of the basic knowledge primary school teachers will need, and to outline some of the environmental choices they must consider if they are to function efficiently inside and outside the classroom. The material is by no means exhaustive: there is much more to be investigated. The knowledge and new insights gained by teachers must be passed on to the young through methods which will challenge and involve them. Some methods have ben suggested in this work.

The primary school is the foundation of the educational system: it is a good place to start.

List of tables

Table
no.

List of illustrations

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